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How Automobile Motor Castings Are Molded

A Description of the Molding Methods Employed by the Ferro Machine & Foundry Co.—Core Assembly in Mold is Unique

THE quantity production of automobile cylinders, after Winton, Haynes and Olds first introduced their horseless carriages, resulted from the efforts of a few progressive founders who failed to heed the advice of those who said, "It can't be done". From the time of the casting of the first horizontal-opposed, 2-cylinder engine this deadly incubus has stood at attention, ready to block every move the progressive foundryman might make or to deride any radical change in design suggested by automobile engineers. However, nothing succeeds like success, and today the many foundrymen in the motor car field seem willing to try any new scheme that promises an increase in quality or production regardless of the absence of precedent. When the motor vehicle first became a commercial possibility, a gang of skilled molders were proud of a day's output of three engine castings. The cores were made laboriously by hand in boxes that had been accepted by the industry as standard for generations. Today, 50, 70 and on some jobs 100 molds requiring greatly increased skill and much more labor are not considered unusual for a day's work. Expediency and accuracy in coremaking have developed at an equal pace. New machinery, improved methods of handling materials and labor-saving devices have played an important part in the wonderful growth and development of this highly specialized branch of the foundry industry. Automobile engine molds are steadily becoming more complicated. The simple 2 or 4-cylinder mold was first on the scene. Soon crank cases were added; then sixes, eights and twelves came in quick succession. A 12-cylinder mold including the crank case is the last word at present in automobile engine molding and casting in the foundry.

Perhaps no one factor has had more influence upon this particular branch of the industry than the general recognition of the skilled engineer as essential to the advance of foundry practice. To the technically trained man belongs a large share of the credit for the development of standardized methods of quantity production and for the inauguration of new machinery and devices to economize labor and to secure accuracy. The foundry of the Ferro Machine & Foundry Co., Cleveland, affords an unusual demonstration of results of the development of new ideas and the improvement of old theories of foundry practice. In the core rooms of this plant, which were described in the July number of THE FOUNDRY, the evidence of intensive standardized production is clearly discernible. Ideal foundry operation is theoretically, a comparatively simple problem if but one particular casting is to be produced. However, when some 30 separate jobs must be handled in one foundry, the problem becomes more difficult. The wide variation that exists between the molding and core-

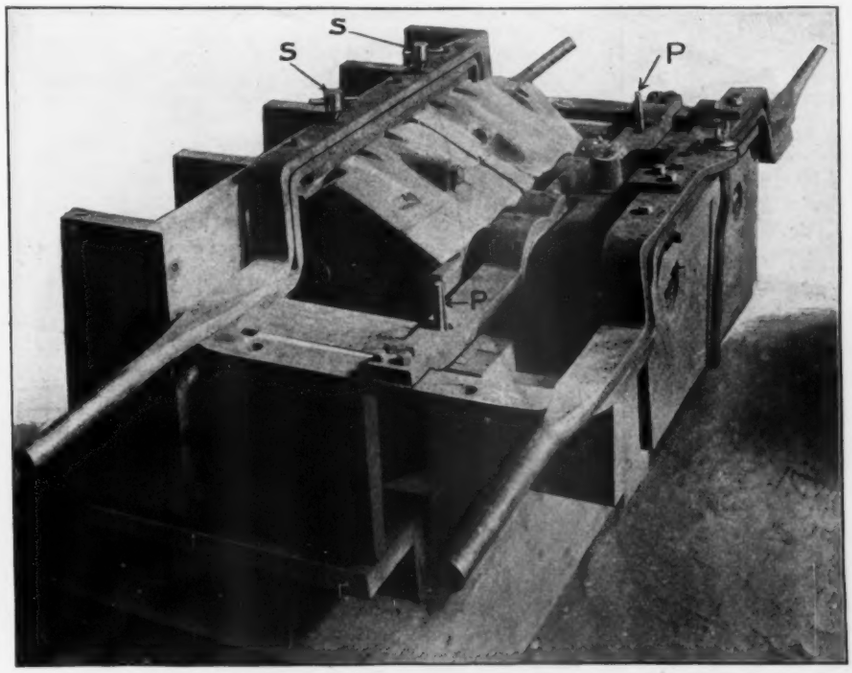


FIG. 1—ASSEMBLED CORES READY TO BE PLACED IN THE DRAG—THE SCREWS *SS* SCREW INTO ARBORS IN THE CRANK-CASE CORE

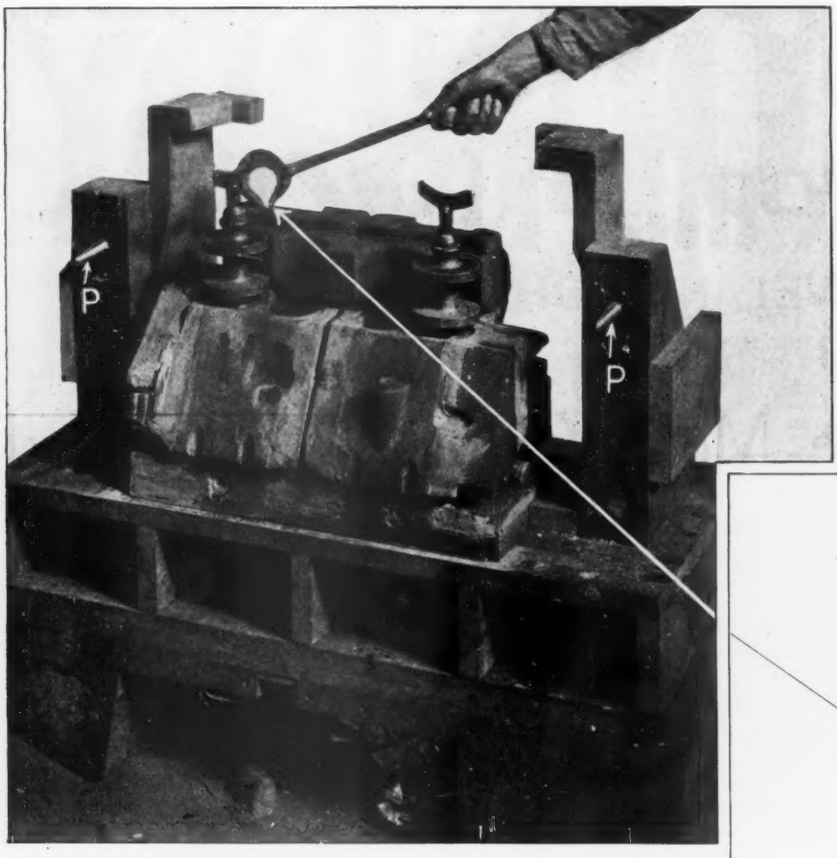


FIG. 2—LEADING THE SPRING-HOUSING CORE TO THE CRANK-CASE CORE, AN EARLY STEP IN THE CORE ASSEMBLY

FIG. 3—THE COMPLETELY ASSEMBLED CORES ARE HELD RIGIDLY TOGETHER BY MEANS OF TWO BOLTS PASSING THROUGH THE END BARREL

making operations for a 1-cylinder motorcycle engine and those necessary for a submarine-chaser motor indicates fairly well the nature of the work done in the foundry of the Ferro plant.

The foundry is divided into four main sections which are devoted to the production of motor castings of various sizes and of miscellaneous pieces such as bell housings, pump cases, cylinder heads and transmission cases. All automobile engine castings are made on the main floor in the west, east and south bays. Part of the miscellaneous work is handled in the east bay; the remainder is molded

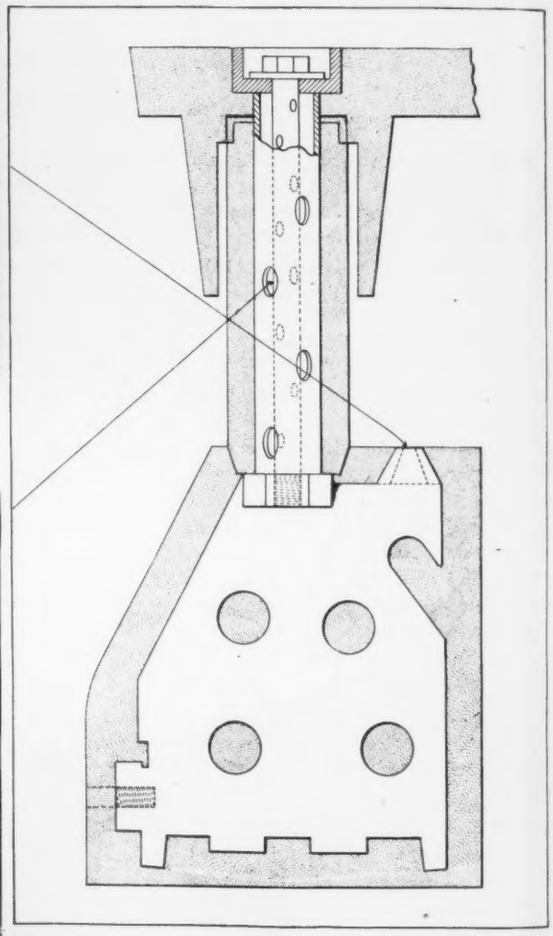


FIG. 4—DETAIL SHOWING HOW THE ARBORS ARE PLACED IN THE CORES

and cast on the floor above. The molding floors are divided into units each equipped to mold but one job. These individual floors are supplied with roll-over, jar-ram cope and drag molding machines, assembling jigs and other equipment to produce the particular mold to which the unit is devoted. A view of the main molding floor in the west bay where a number of different types of automobile engines are molded is shown in Fig. 5. This illustration also shows the arrangement of the service cranes

FIG. 5—MOLDING FLOOR IN THE WEST BAY SHOWING CRANE FACILITIES AND TRAMWAYS FOR CARRYING THE MOLTEN IRON—THE FOUNDRY IS WELL LIGHTED AND VENTILATED

FIG. 6—THE FOUNDRY IS DIVIDED INTO A NUMBER OF COMPLETE, INDIVIDUAL MOLDING FLOORS—THIS ILLUSTRATION SHOWS THE EQUIPMENT ON ONE OF THESE FLOORS

FIG. 7—CLOSING THE MOLD FOR A LARGE 6-CYLINDER ENGINE IN ANOTHER PORTION OF THE WEST BAY

which are used for handling empty flasks, placing the copes on the drags and similar work. The cranes are of 2-ton capacity. They were built by the Johnson & Jennings Co., Cleveland, and were furnished by the Euclid Crane & Hoist Co., Euclid, O. The west and south bays are served by six and four of these cranes, respectively.

Molds poured during the day are broken up and cleaned by laborers on the night shift. About 225 men are employed on this shift. A large percentage of the sand is reclaimed by passing it through ⅜-inch mesh screens, mixing sufficient new sand with the old to provide the proper cohesion. Enough flasks are supplied to each floor to meet the requirements of the day's output. The general arrangement of a single floor showing the empty flasks and the two molding machines is illustrated in Fig. 6. A double line of completed molds may be seen in the foreground. Fig. 7 shows one of the larger engine molds being closed.

One of the most prominent features in the development of foundry practice to produce large quantities of automobile castings is the tendency to use jigs for assembling the various cores and molds. Although jigs have been used extensively for some time in corerooms for assembling cores and finishing them to the proper shape, this means of saving time and of assuring accuracy has not been extended generally to the molding floor until comparatively recently. Several ingenious devices have been adapted by the Ferro foundry to secure precision in the placing of the cores in the mold, to effect the desired distribution of the metal in the casting and to accelerate production.

A typical example of the use of assembling devices on the molding floor is illustrated by the preparation of the molds for a 4-cylinder truck engine. The cores are assembled in a wooden jig hinged to a platform. The crank-case core is first slid into the base of the frame or jig, being located accurately by several blocks against which it is pushed. After the crank-case core has been set in its place in the jig, two special fixtures which serve to locate the spring-housing core are screwed into position, as shown in Fig. 4. The two steel arbors around which the crank-case core is rammed, the upper surfaces being flush with the two outer barrel core prints, are provided with threads to receive the two special fixtures. The position of these arbors in the core is shown in the core-assembly drawing, Fig. 4, and by the arrows and dotted lines in Figs. 2, 3 and 4.

The arbors also provide a means of fastening the valve spring-housing core to the crank-case core. The

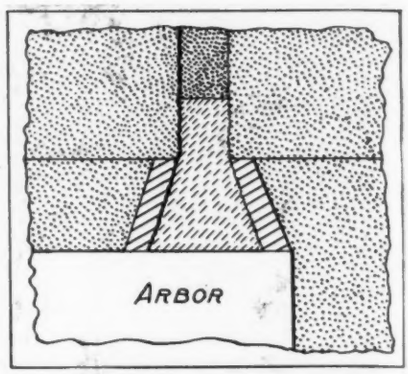


FIG. 9—HOW LEADING FASTENS THE SPRING-HOUSING CORE TO THE CRANK-CASE CORE

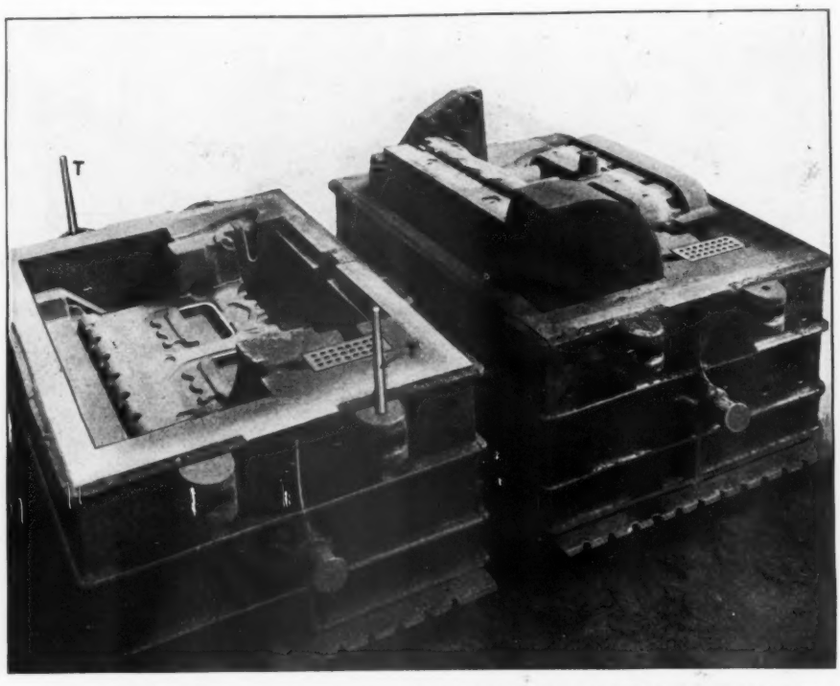


FIG. 8—THE PINS *TT* SLIP THROUGH HOLES IN THE JIG SERVING TO LOCATE THE CORES ACCURATELY IN THE MOLD—THE MOLD TO THE RIGHT IS READY TO BE CLOSED

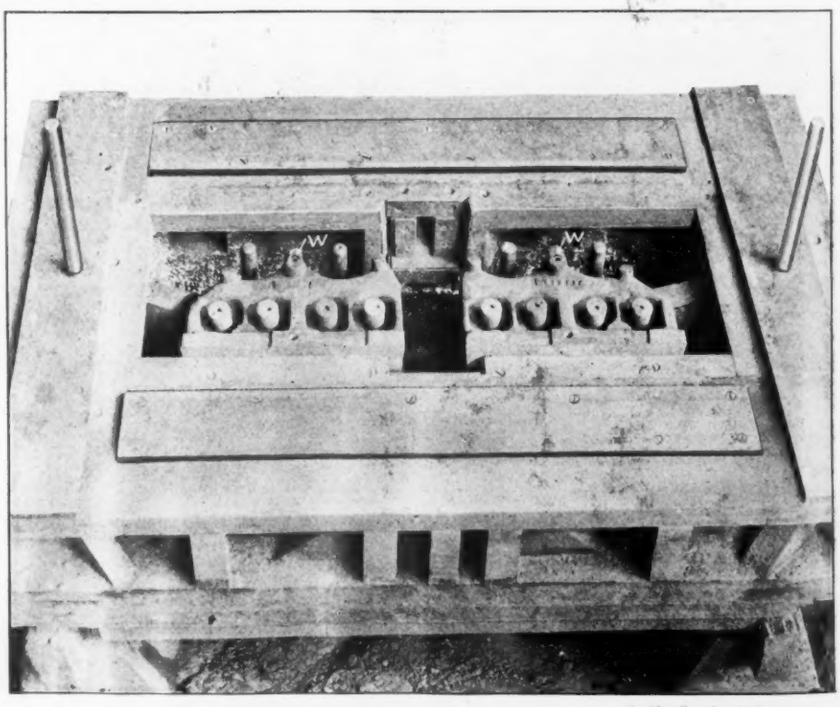


FIG. 10—JIG FOR HOLDING CORES WHILE THEY ARE BEING LEADED TO GREEN-SAND MOLD—THE LEAD IS HELD BY LOOPS OF WIRE AT *WW*

manner in which this is accomplished is indicated by the diagram shown in Fig. 9. Molten lead, which is poured into small holes, projects through the spring-housing core, piercing the under surface immediately above the hole in the part of the arbor which is flush with the surface of the crank-case core at this point. Fig. 2 shows how the assembler performs this operation. The lead flows into the conical-shaped opening in the arbor and into the ports of the sand and, on hardening, firmly binds the two cores together. Talc paste is used to plug the two holes after leading. The two special fixtures for locating the spring-housing core are removed and the barrel or cylinder cores are pasted in their proper positions.

The two end cores are made around steel arbors similar to the one shown at *A* in Fig. 13. The cylinder-head core is set in place and bolted securely to the barrel and crank-case cores by means of two long bolts which pass through the arbors in the outer barrel cores and screw into the crank-case core arbors. Fig. 3 illustrates this last step in the assembly and shows how all the cores are brought to correct relation with one another by tightening the two bolts.

Setting the Cores in the Drag

In this condition the completely assembled cores are ready to be placed into the drag. Tipping the jig forward on the hinges provided for this purpose brings the cores into a horizontal position ready to receive a steel skeleton jig which is used to carry the cores to the drag. Holes in this jig slipping over the pins shown at *P P* in Figs. 1, 2 and 3 serve to align the cores in the jig. After tightening the thumb screws, which screw into the arbors and which are indicated at *S S* in Fig. 1, the cores are carried to the drag, being guided into the proper position by the long tapering pins, *T T*, Fig. 8. This illustration shows a drag ready to receive a completely assembled core and one with all the cores in place waiting for the cope to be dropped into place to close the flask. The fly-wheel housing and the gear cores are set in the mold by hand after the jig-assembled core has been set.

This method of core assembly possesses several advantages. By locating all the cores of the several components of the engine casting with reference to one of the cores, the correct alignment of these parts is assured; the crank and the cam bearings will be accurately located and the desired thickness of metal will be secured when the metal is poured into the mold. The rigidity obtained by bolting the several cores together minimizes the danger of any of the cores slipping under the stress or pressure of the molten metal as it flows into the mold. Chaplets are made unnecessary by this scheme. Not only does this method enhance the precision of the work, but it also makes possible the use of unskilled labor to assemble a large number of cores in a minimum of time.

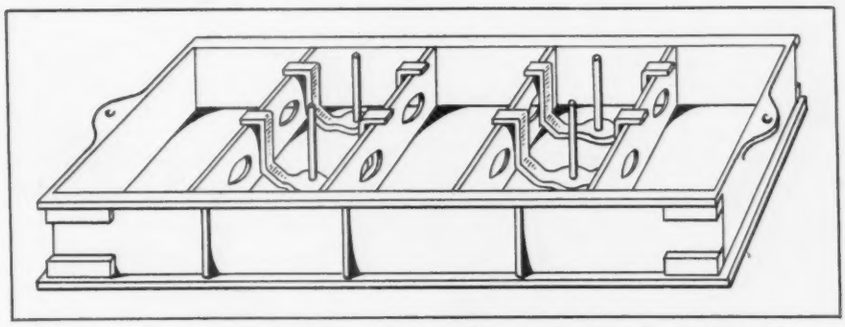


FIG. 12—DETAIL OF COPE SHOWING HOW BRIDGES ARE PLACED TO SUPPORT THE CORES

Division of Labor

Copes for the molds for this 4-cylinder engine job are made by three men who operate a roll-over, jar-ram molding machine made by the Osborn Mfg. Co., Cleveland. The drags are molded on a similar machine made by the International Molding Machine Co., Chicago. This work is handled by two men. Three men are kept busy placing the cores in the molds. One man working on the jig assembles sufficient cores to keep up with the rest of the crew. These nine men, together with two laborers who carry the assembled cores, etc., are able to close 50 molds in one day.

Another unique application of the use of lead is a scheme to anchor cores to green sand molds, as illustrated in Figs. 10, 11 and 12. On this job a small 8-cylinder motor, the spring-housing core is leaded to small straps placed in the flask before it is rammed. The arrangement of these straps or bridges is indicated by the sketch shown in Fig. 12. While the flask is being rammed, small rods, about ¼ inch in diameter, are set into the conical openings in the straps and allowed to project through the sand to provide a gate for the molten lead. The spring-housing cores are held in a jig, Fig. 10, on which the cope is placed. When the molten lead is poured through the holes in the cope it flows under small loops of wire which are rammed in the cores, as indicated at *W* in Fig. 10. After the lead has solidified,

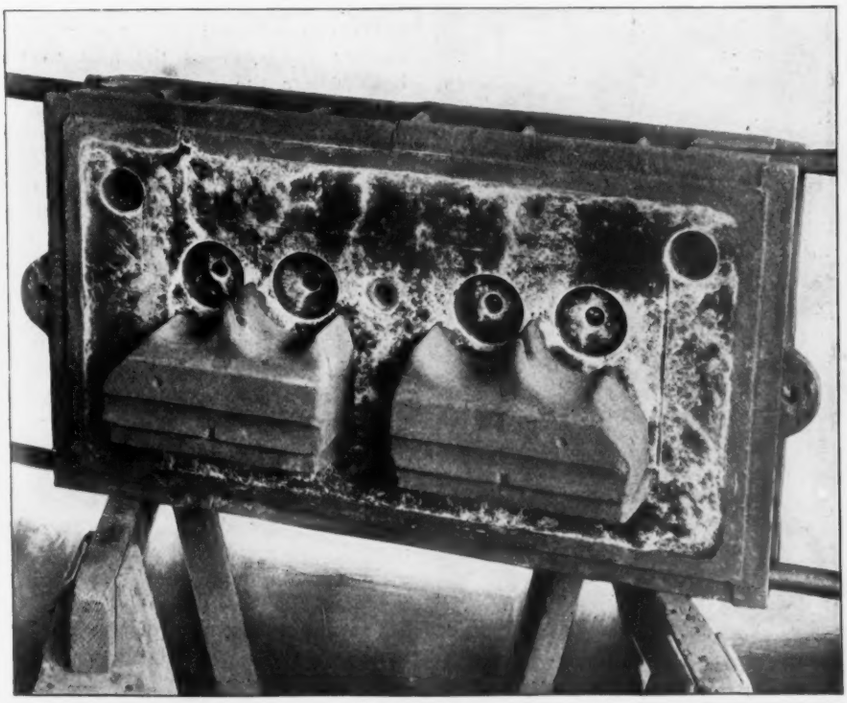


FIG. 11—AFTER LEADING THE CORES ARE HELD SECURELY TO THE COPE

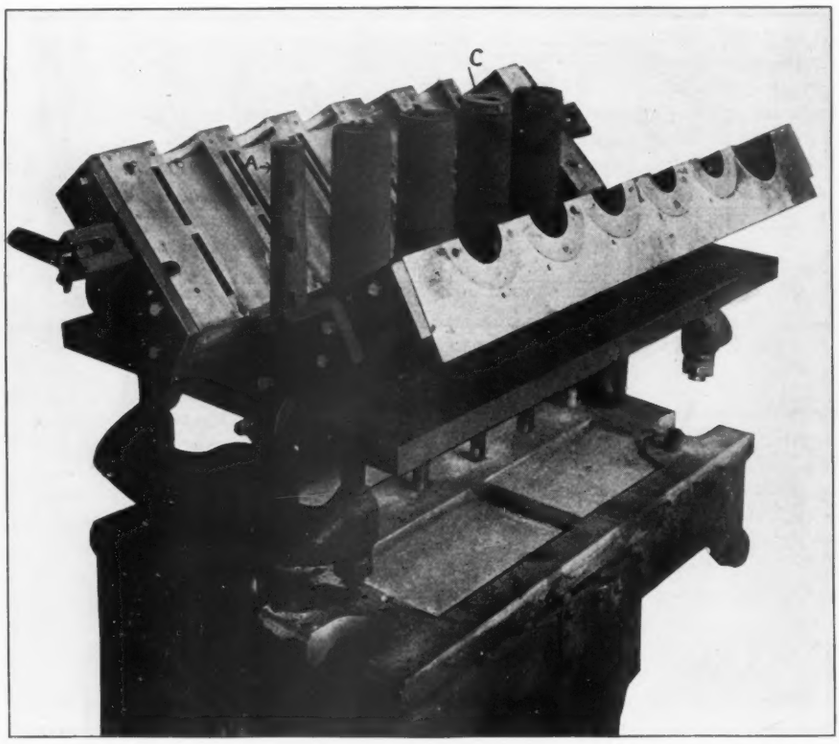


FIG. 13—MOLDING MACHINE FOR MAKING GREEN-SAND BARREL CORES

the cope is lifted from the jig, the core being accurately located and securely fastened, as shown in Fig. 11.

Green Sand Cores

Cylinder-barrel cores for several of the jobs which are assembled by bolting, as outlined in previous paragraphs, are made on a special jolt machine built by the Osborn Mfg. Co., Cleveland. Green sand cores are used. This machine, which is shown in Fig. 13 in position for removing the cores, makes six cores at one time, either with or without the arbors. The slots in the arbor shown at *A* in this illustration provide an exit for the gases. The arbors are coated with a paste before ramming to make the sand stick and are tapered to facilitate removal after the cores have been used. By changing the sleeves which form the outer surface of the cores, a number of different sizes and shapes may be produced on the one machine. The cap that is placed on the end of the core fitting into the cylinder-head core is shown at *C*, in Fig. 13.

Pig iron for the cupolas is unloaded from the freight cars by a locomotive crane furnished by the Browning Co., Cleveland. This crane is equipped with a magnet made by the Electric Controller & Mfg. Co., Cleveland. The coke is dropped into a coke-storage pit from hopper cars. Both the pig iron and the coke are transported to the charging floor in small cars drawn by an electric truck. Two cupolas located in the approximate center of the foundry are used to prepare the iron for pouring. The average daily melt is from 100 to 130 tons.

Special Features of Cupolas

The cupolas, which were built by the J. W. Paxson Co., Philadelphia, are provided with six upper or secondary tuyeres at the top of the bosh. These tuyeres are equipped with independent lever gates. While the lower tuyeres give a nearly continuous opening providing a low air velocity, the six smaller openings of the upper tuyeres introduce air at a higher velocity and, it is said, serve to furnish a draft for the escaping gases. It is claimed that this assists combustion and confines the heat to the bosh where the melting action takes place. The introduction of a large volume of air into the melting zone, at a low pressure and velocity, tends to supply the oxygen evenly, thus producing rapid and even melting. Air is supplied to the cupolas by two blowers built by the Connersville Blower Co., Connersville, Ind., driven by 50-horsepower, alternating-current motors manufactured by the Burke Electric Co., Erie, Pa.

The metal is carried from the cupolas to the molds on tramways or monorails. Pouring usually is started about two hours after the molding crews start in the morning, continuing throughout the day. After they are poured, the molds are allowed to remain on the floor until night, when they are shaken out by laborers.

The entire basement of the foundry building is devoted to chipping and cleaning. Various castings are brought from the foundry to this de-

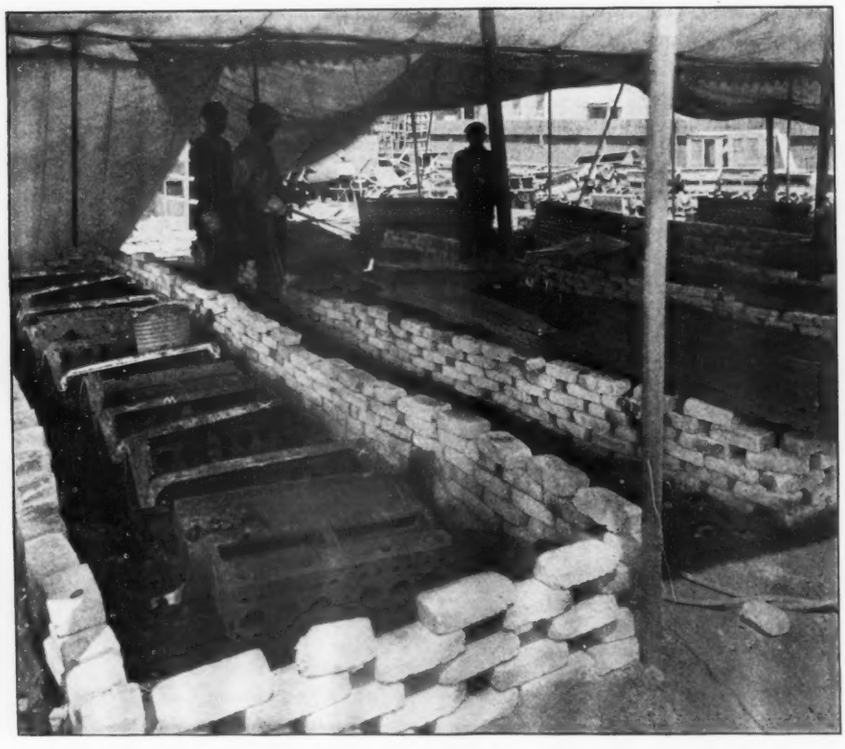


FIG. 14—DURING THE SUMMER MONTHS THE CASTINGS ARE WELDED IN A LARGE TENT—CRUDE CHARCOAL OVENS REPLACE THE GAS OVENS TO BE FOUND REGULAR DEPARTMENT

partment on an elevator, from which they are transferred to the sand-blast rooms. Equipment furnished by the W. W. Sly Mfg. Co., Cleveland, and the Pangborn Corp., Hagerstown, Md., is used in the two sanding rooms. After being cleaned by sand blasting, the larger irregularities in the surfaces of the castings are removed by seven grinders of the swing-arm type.

At this stage, first inspection takes place. This division of the work is handled by five men who inspect the castings on low steel tables. The castings are chipped by a crew of 50 men using air hammers made by the Pittsburg Pneumatic Co., Canton, O. About 35 of these men devote their attentions to cylinder castings; the remainder chip miscellaneous castings. A water-test of the cylinders follows the chipping operation. In this branch of inspection, 15 men apply water to the castings at 100-pound pressure. If leaks are indicated by this test, the castings are sent to the welding department, or, if the fault is too severe, the cylinders are scrapped.

Small cylinders, cylinder heads and similar castings are tumbled in a battery of twenty-six 30 x 36-inch barrels. Four large 48 x 80-inch barrels made by the Sly company are used for the heavier pieces. The final grinding of the castings for finishing is accomplished on a battery of seven pedestal-grinders. All grinders and tumbling barrels are supplied with dust exhausters.

Outdoor Welding Department

Small cracks and surface defects in the castings are eliminated by the application of the oxy-acetylene flame. Three gas-fired furnaces having an individual capacity for six large cylinder castings or 18 small ones heat the castings preparatory for welding. Gas for this process is generated in the plant by equipment furnished by the Oxweld Acetylene Co., Chicago. In the summer months, when the warm weather coupled with the heat from the furnaces and the welding flames almost precludes the use of the equipment in the cleaning department, a large tent is erected near the cleaning room and the castings are heated by charcoal in brick ovens and welded by means of portable equipment. The general arrangement of this humanitarian expedient is illustrated in Fig. 14, which shows how the castings are placed in the furnaces and packed with charcoal. The portable welding apparatus was manufactured by the Prest-O-Lite Co., Indianapolis.

The final inspection of the day's output of 1100 or 1200 cylinder castings takes place on the main floor of the building near the shipping platform. Tests to ferret out any defects such as those resulting from cores being set off-center are conducted in this department. Various jigs and gages are fitted to the castings before they are finally released to the shipping department.

How Malleable Iron Has Improved

By Enrique Touceda

I HAVE been asked to prepare an outline containing data that might assist in indicating the progress that has been made during the past few years in the improvement of malleable iron. It is believed this can best be done by tabulating the results of many hundreds of tests, starting from the time they began to be systematically conducted, presenting the averages in suitable form.

While prior to November, 1915, tensile test bars were sent me by the various concerns for whom I am consulting engineer, with frequency, but at odd intervals, it was not until the date referred to that it was decided to send on test bars daily which would fairly represent the product of each day's run.

The record that will first be presented consists of the average ultimate strength and elongation of all bars received during the last two months of 1915; of all bars received during the whole of 1916; and of all bars received during the first five months of 1917.

To the end that you may obtain a clearer idea of what these tests indicate than if you were furnished simply with the average ultimate strength and elongation of the total number of bars received during these various periods, the results have been classified into various grades, as shown in Table II. About 18 separate companies furnished these bars. Therefore, this data is derived from tests of bars sent me by a very significant number of concerns.

Looking over my records prior to the year 1914, in which there is abundant data, it was found that the average ultimate strength and elongation would approximate about 38,000 pounds ultimate and 3.50 per cent elongation respectively though there are occasional instances of a 46,000 and 48,000 pounds only with a 6 or 7 per cent elongation. On looking over these old records it is found that the test bars then submitted were of many different dimensions varying anywhere from ½ to 1 inch in diameter, while some were square and others rectangular in section. For this reason it is hardly possible to gather from this data any conclusions which can be compared accurately with the material that has passed through my hands since the beginning of 1914.

Table I

Data Demonstrating Uniformity

JUNE RECORD, FOUNDRY A

Ultimate strength, lbs. per sq. in.	Elongation in per cent
46,032	8.59
50,631	8.59
46,700	8.59
50,213	8.59
46,917	7.03
48,344	7.03
47,324	6.25
54,028	9.38
46,540	8.59
48,761	7.03
51,012	9.38
49,255	7.81
47,706	7.81
52,422	7.81
50,733	9.38
47,444	9.38

JUNE RECORD, FOUNDRY B

Ultimate strength, lbs. per sq. in.	Elongation in per cent
50,338	12.50
51,734	16.41
52,343	18.75
52,011	15.63
50,937	13.28
50,700	10.94
51,938	14.84
49,899	14.84
51,476	14.84
52,780	11.72
50,400	9.38

It will be noted in Table II that the proportion of the 1915 bars that failed to test up to 40,000 pounds was 5.80 per cent. In 1916 this ratio dropped to 2.57 per cent, and in 1917 to 1.68 per cent. Only 2.40 per cent of the bars exceeded 52,000 pounds per square inch ultimate in 1914, as against 16.76 in 1916, and 18.49 per cent in 1917. In 1914, 72.35 per cent of the bars exceeded 44,000 pounds per square inch ultimate, while in 1915, 86.42 per cent, and in 1917, 88.85 per cent exceeded that figure.

When the great difficulty that has been encountered by the manufacturer within the past six months in securing suitable coal and iron for his pur-

A paper presented at the Boston meeting of the American Foundrymen's association. The author, Enrique Touceda, is consulting engineer, Albany, N. Y.

pose is considered, the continued improvement in 1917 is certainly quite remarkable, as the handicap has been very large.

Another important fact that can be gathered from the data in Table II is that malleable iron of good quality is very different from other ferrous products in one particular, in that its elongation increases with its ultimate strength. Prior to the discovery of this fact it had invariably been assumed by all writers on this subject that the reverse was true.

Table II

Summary of Tests of Malleable Iron

	Per cent of bars under 40,000 lbs. ultimate.	Per cent of bars between 40,000 and 42,000 lbs. ultimate.	Per cent of bars between 42,000 and 44,000 lbs. ultimate.	Per cent of bars between 44,000 and 46,000 lbs. ultimate.	Per cent of bars between 46,000 and 48,000 lbs. ultimate.	Per cent of bars between 48,000 and 50,000 lbs. ultimate.	Per cent of bars between 50,000 and 52,000 lbs. ultimate.	Per cent of bars over 52,000 lbs. ult.
1915—Covering last two months:								
Ave. ult. lbs. per sq. in.	5.80	9.47	12.38	21.44	21.15	16.22	11.05	2.49
Ave. elong. per cent in 2 in.	4.91	6.55	7.38	8.87	9.47	10.17	11.27	13.38
1916—Entire year:								
Ave. ult. lbs. per sq. in.	2.57	3.65	7.36	13.64	18.26	21.57	16.61	16.76
Ave. elong. per cent in 2 in.	5.78	6.88	7.48	8.33	9.14	10.28	11.61	12.72
1917—Covering first five months:								
Ave. ult. lbs. per sq. in.	1.68	2.75	6.72	12.83	20.53	20.22	16.78	18.49
Ave. elong. per cent in 2 in.	5.78	7.37	8.20	8.72	10.11	11.51	12.97	14.94

All bars ⅝-inch diameter, and similar in all particulars to the tensile test bar recommended by the A. S. T. M. in its specifications for malleable iron.

While it is believed the foregoing data unmistakably demonstrate the fact that a healthy improvement in the quality of malleable iron has taken place within the past few years, they do not tell the whole story. One of the most serious shortcomings in malleable iron in the past has been its lack of uniformity. I consider the improvement that has been accomplished in this direction within the past few years to have much more far-reaching effect on the user of this metal, and to be of greater importance to him than the ability of the founder to obtain high strength and ductility. A high ultimate strength is not always specified owing to the belief on the part of some that when the ultimate strength is in the neighborhood of 42,000 pounds per square inch the machine tools can be speeded up to a considerably higher rate than is possible when working with metal having ultimate strengths around 48,000 to 50,000 pounds. This is a matter we will not discuss at the present time. If the individual record of many of the concerns, the results of whose physical tests are included in the data in Table II were examined, it would be found that they have made a practically uniform run day in and day out for a period covering many months. Those whose showing is more erratic are improving in this particular from month to month.

The figures in Table I were taken from records covering iron made during June. These data demonstrate the uniformity in the quality of the material from many consecutive heats, illustrating the fact that the manufacturer of malleable iron who is well posted in malleable practice has full control of his product. The day of "hit or miss" has passed.

Table III, however, records a run of 17 consecutive heats made during February, of this year. The average ultimate strength of the 17 bars is 52,784 pounds and the average elongation is 17.88 per cent, in spite of the fact that two of the bars contained a slight shrink which made them fail prematurely. In this set there are four bars with over 21 per cent elongation; one with 24.22 per cent, and one with 27.34 per cent. We have tested many bars within the past two years having an elongation as high as 24.00 per cent, but it is believed that 27.34 per cent is the record elongation of any malleable iron test bar ⅝-inch diameter yet produced. I might add that the reduction of area of this bar was 22.71 per cent. The data in this table are furnished because they clearly demonstrate what is possible to achieve along the line of quality and uniformity, the goal toward which we are aiming.

As I have made mention of no tensile tests aside from those made on the standard tensile test bar recommended by the American Society for Testing Materials, it may be of interest to make record of the results of tests on bars with different-sized sections. Some four months ago six sets of bars cast from the same heat and of these sizes were sent me:

Set No. 1, 12 bars, ⅝-inch diameter.
Set No. 2, 6 bars, ¾-inch diameter.
Set No. 3, 6 bars, ⅞-inch diameter.
Set No. 4, 6 bars, 1 -inch diameter.
Set No. 5, 6 bars, 1⅛-inch diameter.
Set No. 6, 6 bars, 1¼-inch diameter.

The *average* results are as follows:

Set marked	Ultimate strength lbs. per sq. in.	Elongation in per cent
No. 1— ⅝-inch	52,141	15.62
No. 2— ¾-inch	48,062	10.54
No. 3— ⅞-inch	47,107	9.37
No. 4—1 -inch	47,317	11.56
No. 5—1⅛-inch	47,148	9.69
No. 6—1¼-inch	46,592	9.69

The foregoing table should serve as a complete answer to those who maintain that when malleable iron exceeds ⅝-inch it cannot be made strong or ductile. Our experience indicates that provided a casting is sound, high quality malleable iron can be produced today just as easily in sections around 1¼ inches thick as in the case of ⅝-inch sections. With increased thickness there naturally comes increased difficulty in removing all the shrinks, but we have within the past few years made great strides in the direction of securing perfect soundness in thick and intricately designed castings.

In short, great progress has been made in improving the physical properties of malleable iron solely and only because of a determination on the part of the manufacturers to systematically improve each step in the process. It is believed that the figures placed before you indicate that they have more than achieved a fair measure of success.

Table III

Tests Reveal Average High Quality

FEBRUARY FOUNDRY RECORD

Ultimate strength, lbs. per sq. in.	Elongation in per cent
55,032	21.09
53,908	21.09
54,706	21.09
52,010	17.19
50,321	10.94*
54,867	17.19
54,283	13.28
53,537	21.09
55,804	27.34
51,380	11.72
51,978	24.22
52,506	17.97
52,477	17.19
50,097	14.06
49,910	12.50*
52,204	17.97
52,311	17.97

*Test bar broke in fillet.

Steel Castings For Ordnance Construction

The Second Installment of an Article Describing the Methods Employed in the Steel Foundry of the United States Arsenal at Watertown

By Major C M Wesson

I PREVIOUSLY referred to the earlier difficulties in procuring steel castings some 17 years ago. Today the situation as regards the larger castings of the lower grades is satisfactory, but as regards the small higher grade castings, it is still far below what it should be. The Rock Island arsenal and the large private ordnance manufacturers have been having great difficulties in securing satisfactory small castings. I learned recently that a number of large howitzer carriages, which are being manufactured by a large private corporation, have been greatly delayed in completion, because two separate sub-contracts, which it placed for the small castings involved, had been cancelled on account of failure to deliver them.

In connection with this subject, I quote from an official letter of recent date as follows:

"A reply to preceding endorsement has been delayed with a view to determining what success we would have in obtaining steel castings on existing contracts placed with steel casting manufacturers. * * * The results, except for cast steel No. 1, are very discouraging. Practically all of them make "steel castings," generally without regard to physical qualities. Cast steel No. 3 and No. 2 are almost beyond their ability. Many of them with whom the subject has been taken up knew nothing about physical qualities. We had expected to obtain satisfactory results from the * * * but they are having much trouble with a large order for steel castings No. 3. It is apparently due to their inability to obtain coke with a low sulphur content." As regards this question of sulphur, I personally believe that if the sulphur difficulties are not sufficient to prevent the production of the No. 2 grade, there should be no reason why the No. 3 grade could not be made.

Satisfactory small steel castings of both the No. 2 and No. 3 grades can be made, and by any of you who possess ordinary foundry equipment, if you will take the precautions to procure suitable material, and exercise the proper care as to details. These latter extend not only to the production of the metal itself, but include the essential items of mold treatment, molding sand, gates, risers, etc. The best metal that can be produced will result in porous or cracked castings, if the mold which receives it does not measure up to certain requirements. This problem of the mold you are meeting every day in castings demanded for the motor-car industry, and others where intricacy of pattern equals, or is greater than that encountered in ordnance work.

In the remainder of this paper are outlined the basic features on which the practice at the government arsenal at Watertown rests. No claim is made to originality. The practice outlined is believed to represent good methods. Unquestionably, there is large room for improvement. The equipment of the foundry at Watertown arsenal may be subdivided under the following headings: (1) Molding, (2) drying, (3) melting, (4) annealing, and (5) cleaning.

The molding equipment consists of one jar squeezer for brass work, 22 x 26-inch table, 36 inches between supports; one 6 x 4-foot jolt machine; one

Second and final installment of a paper read at the Boston meeting of the American Foundrymen's association, Sept. 24-28. The author, Major C. M. Wesson, is officer in charge of manufacture Watertown Arsenal, Watertown, Mass.

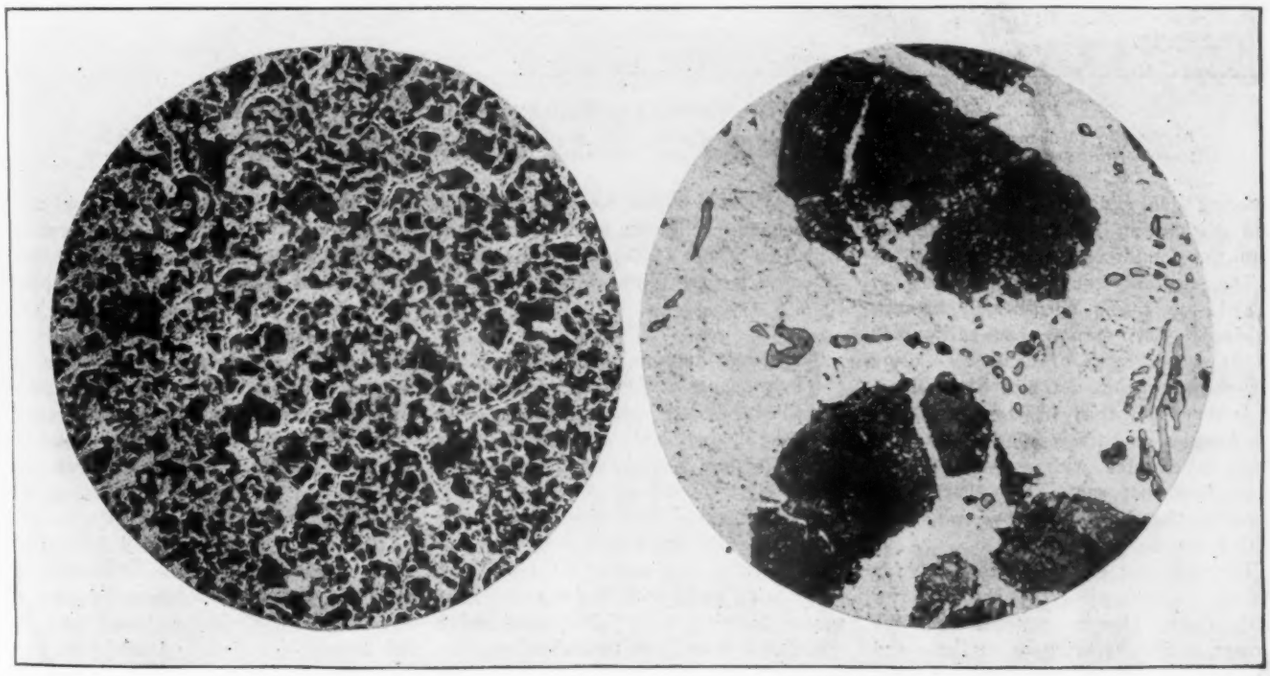


FIG. 1—MICROSTRUCTURE OF NO. 3 CAST STEEL DEFICIENT IN DUCTILITY

At the left, 50 diameters; at the right, 500 diameters. Carbon, 0.42 per cent; manganese, 0.72 per cent. Yield point, 52,500 pounds per square inch; tensile strength, 85,500 pounds per square inch; elongation, 9.5 per cent; contraction, 9.5 per cent

3 x 3-foot jolt machine; and one 18 x 24-inch jolt machine.

These machines are used for jolting dry or green sand steel work, small and medium in weight, also the small jolt is used for jolting snap-flask work, often with two flasks on one board. Heavy air rammers and light bench air rammers are largely used by the molders and are popular.

The drying equipment consists of one mold oven, 24 x 19 x 9 feet high; one mold oven, 22 x 15 x 10 feet high; one core and snap flask mold oven, 20 x 9½ x 10 feet high and one core oven, 18 x 6 x 10 feet high. The latter is served by two narrow gage cars, the oven opening at both ends and the cars entering one end from the core room and discharging from the opposite end into the foundry.

The melting equipment consists of one 15-ton tilting open-hearth furnace, oil-fired. This furnace can easily melt 15 heats per week of acid steel, using low-phosphorus stocks and steel scrap. It is served by thirty 3000-pound charging buggies on narrow gage tracks. All stock is elevated with a 3-ton electric hoist from flat cars. The charging is done by hand, assisted by two 1000-pound air hoists.

The converter equipment consists of a 2½-ton side-blow Tropenas converter with Roots blower, motor-driven, the blower equipment being in duplicate and one 42-inch cupola with charging platform 15 feet above the level of the foundry floor.

The charging platform is served by an elevator of about 10 tons capacity.

The equipment for melting alloy additions for the converter metal consists of drip-pan, oil-fired furances, served with chain hoists and overhead telpher. The ladle equipment consists of two 20-ton open-hearth ladles, bottom pour, and the usual number of top-pour worm-gear foundry ladles, from five tons capacity down; also one 2-ton bottom pour ladle for handling iron and steel from the converter. The ladles are heated by top fired combustion chamber ladle heaters.

In addition to the foregoing there are five coke-fired individual pot brass furnaces, taking pots up to No. 300.

The melting and molding bay is approximately 48 x 300 feet and is served by one 10-ton crane; one 20-ton crane with two 10-ton trolleys, and one 30-ton crane with two 15-ton hoists.

Annealing

The annealing equipment consists of two car bottom furnaces which are described in more detail later.

The chipping and cleaning shop is served by one 5-ton electric hoist; two 3-ton electric hoists; one 5-ton jib crane and additional chain hoists; three oxy-acetylene cutters and welders; one high-pressure two-nozzle air blast, the room being large enough for two 5-foot square buggies; one 8-foot sand mill; three cold saws; one two-wheel stationary grinder; and two cold saws for bronze work.

Castings to meet the various grades specified above, or special grades of alloy steel castings when so specified, are produced in weights from a few ounces to 15,000 and 18,000 pounds each. Many of the castings are made from individual patterns, the orders for castings from each pattern usually not exceeding 100, many times not exceeding 10 to 20. Many of the sections of the smaller castings being very light and the design intricate, necessitates complicated core work and careful molding. Releasing to prevent hot checks and cracks is often necessary. Many of the heavier castings weighing from 2000 to 5000 pounds are bulky and of easy sections, some sections being 6 to 8 inches thick. Some of the heavier and thinner sections are as low as 1 inch in thickness, and hence difficult to produce. It will thus be seen that there is a great variety of castings being produced.

Nearly all of the work is made in dry sand, using various mixtures of silica sand, silica rock, heap sand, clay and molasses water. The mixtures are transferred to the molding floor in wooden boxes. These mixtures are worked out by the superintendent and the foreman according to the nature of the work, and are varied from time to time according to the available materials. A large percentage of ground silica rock has always been used by the arsenal foundry, and while its cost has been considerably greater than the cost of an equivalent amount of 98 per cent pure silica sand, the results have been so satisfactory that its use

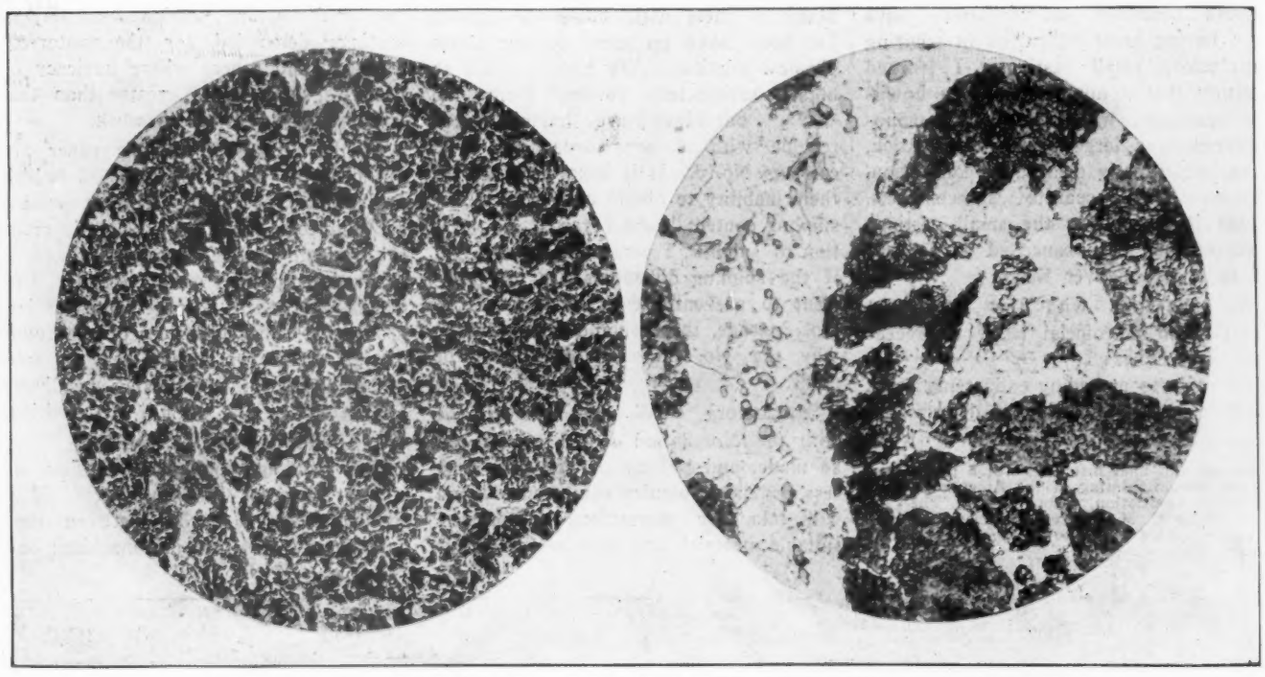


FIG. 2—MICROSTRUCTURE OF ANOTHER SPECIMEN DEFICIENT IN DUCTILITY

At the left, 50 diameters; at the right, 500 diameters. Carbon, 0.43 per cent; manganese, 0.72 per cent. Yield point, 51,500 pounds per square inch; tensile strength, 86,500 pounds per square inch; elongation, 7.5 per cent; contraction, 13.3 per cent

has been considered well justified. There has been an unusual lack of the most common foundry troubles, such as scabs, drops, washers, crushers, broken cores, etc., and the cost of cleaning and chipping off of burned sand adhering to the castings has been found to be quite low. The use of old heap sand in the mixture of stronger facings has been kept down to a minimum, and while its use might possibly be increased in some cases, any great increase would probably show a corresponding increase in expense of cleaning and losses due to defective castings.

Due to the fact that virtually all of the arsenal castings are subject to specifications to meet difficult service, and many of them are machined all over and practically all of them machined in part, it has been found difficult to satisfactorily produce much of such work in green sand. Occasionally, the percentage of work made in green sand can be increased.

There is no jar-squeeze work done. There is a small amount of straight jolt work done on the small jolt machines, using snap flasks; all such work being dried. There is a considerable amount of small and intermediate work from individual patterns made on straight jolt machines and these are butted off with hand air rammers. Probably not over 15 per cent of the man hours of the shop are applied on molding machine work.

Whenever possible, castings are gated and poured from the bottom and the usual foundry rules in this respect are followed as to the size of gates to give proper speed of pouring, etc.

The location of risers has been worked out in the superintendent's office, in conjunction with the foremen of the pattern shop and a riser boss. Correct risers have been provided by the pattern shop before the patterns are delivered to the foundry. This makes it possible to be assured that risers of the correct size will be properly located by the molders, even though a new molder may get a pattern with which he is not familiar. Previous practice which has been found satisfactory is thus transmitted automatically to the shop and adhered to. A common rule of keeping the height of riser approximately 1½ times its diameter has usually been found satisfactory. The percentage of riser necessary, naturally varies from almost nothing in some of the very light castings which do not require much feeding to 25 and 30 per cent in the heavier castings which may not solidify for two or three hours after pouring.

The majority of the converter blows are poured into steel castings. All of the small intricate-section snap flask castings are poured from the converter. Many of the medium and fairly heavy castings are likewise poured from the converter metal or from the open-hearth metal alternately, depending upon the desirability at the time. For example, on many of the smaller castings weighing as low as 400 or 500 pounds, which have thick sections and can easily be run with open-hearth metal, it has been found desirable to pour from the open hearth, because the metal is cheaper and slightly more uniform in chemical composition and meets the physical requirements more regularly.

On the contrary, many heavy castings that it would be desirable to pour from the open hearth (castings weighing up to 4000 pounds) may occasionally be poured from the converter metal as would be the case if the converter is running when the mold is ready and the open hearth is not ready or is on an ingot heat. The flasks are thus released and the production kept up although at a slight increase in the actual cost of the molten metal. On all the more important and heavier castings, at least two coupons are cast on the body of the casting. For the less important and lighter castings, either from the converter or the open hearth, two standard test coupons are cast from a single runner. These coupons are approximately 1½ inches at the bottom, tapered to 2 inches for a height of 5 inches and are 6 inches long. These test pieces are poured at about from the middle of the ladle. All test pieces and all castings are stamped cold with heat number and a serial casting number for identification during the manufacture and for record. All ingots, shell or otherwise, are tagged on top by the insertion, while in molten state, of a sheet steel strap stamped with heat number, serial number of ingot and code number of the grade of steel.

A 2½-ton drop-bottom Tropenas converter is used, lined with silica brick:

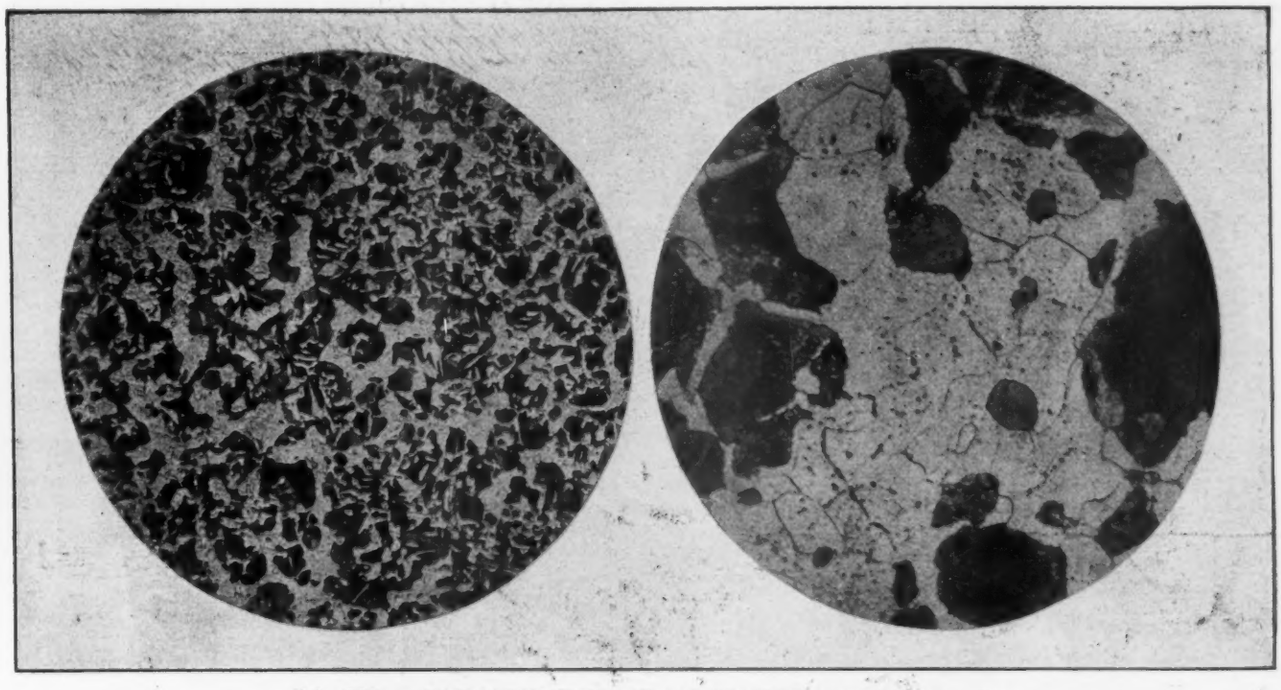


FIG. 3—MICROSTRUCTURE OF SATISFACTORY SPECIMEN

At the left, 50 diameters; at the right, 500 diameters. Carbon, 0.426 per cent; manganese, 0.52 per cent. Yield point, 45,400 pounds per square inch; tensile strength, 85,300 pounds per square inch; elongation, 18.0 per cent; contraction, 23.2 per cent

next to the shell up to the tuyere blocks, the balance of the lining being a ganister mixture, composed of 18 parts of ganister, six parts of silica sand and four parts red clay, bone dry.

One-half of the rock is first put in the sand mill and, after partial grinding (15 minutes) one-half of the clay is added, all of the sand, the balance of the clay and rock in the order named. When sufficiently ground and mixed, it is wet down with thick molasses and water. The mixture is made only as needed as it is found that the results are not satisfactory after the mixture has stood too long. This mixture is used for patching, care being taken not to put the patch over adhering slag. In case of a shallow patch, which might otherwise spall off, a few large nails are inserted into the old lining to assist in holding the patch in place. Before putting on patch, the spot is daubed with thick molasses and also swabbed over with the same material when the patching is completed. Seven brick tuyeres are used. It is very important that the tuyere holes (not tuyere bricks) should always be used in the same horizontal plane when the converter is set plumb. The inside capacity of the vessel and the charge should be regulated in such a way that when blowing, the converter will be set at an angle of about 5 to 7 degrees, in no case more than 12 degrees.

Steel is blown on alternate days, running 8 to 12 blows per day, depending upon the tonnage on the floor to be poured. It is very essential to have ladle and converter thoroughly preheated before starting the first blow. The procedure in the case of the converter is as follows: At 4:30 a. m. the converter is filled with coke to well above the tuyeres and lighted up. From 5:30 to 6:00 the blast is put on, using about 1½-pound pressure. A grating is then put over the nose on the vessel and the converter burned upsidedown until 6:30 a. m. It is then turned up again and the blast put on for another half hour. This process is repeated with coke always well above the tuyere hole, until the vessel shell is approximately the temperature of boiling water. This will usually be between 8:00 and 8:15 a. m.

The pig iron used is high-silicon bessemer of the following specifications: Manganese not to exceed 1 per cent (generally runs about 0.15 per cent); sulphur and phosphorus not to exceed 0.035 per cent; silicon, 2.75 to 3.25 per cent, and copper not to exceed 0.75 per cent.

Crop ends are used, being purchased on same specifications as for the open-hearth. From time to time, a car is picked out which contains a large percentage of pieces of the right size. Normally, gates and risers from castings are used, but if the open hearth is in operation it consumes all of this class of material, and the steel scrap portion of the converter charge is made up of low-sulphur and phosphorus crops, thus always keeping the sulphur well below the limit. The ferrosilicon used is the standard 50 per cent, ferromanganese 80 per cent, and ferrotitanium 15 to 18 per cent.

Cupola

The cupola is 42 inches in diameter with six 7 x 12-inch tuyeres set 16 inches above the sand bottom, the charging door being 110 inches above the tuyeres. Twenty-two hundred cubic feet of air per minute are used, bringing down 5700 pounds of iron about every half hour. The full charge is 5700 pounds, charged in 1425 pounds at a time. The cupola mixture will run from 40 to 45 per cent steel scrap with a coke ratio of about one to seven. By-product coke is used which is low in sulphur and ash, a typical analysis being about 0.53 per cent sulphur and 7.75 per cent ash. Ordinarily, about 20 pounds of lime rock are added to every 5700 pounds charge. This may vary, however, according to the amount of sand adhering to the pig and scrap. In case sulphur is running above the limit desired, 15 to 20 pounds of fine ferromanganese is used in the spout when tapping the cupola or lump ferro is charged in the cupola.

The cupola charge is adjusted so as to give approximately 1.90 per cent silicon; this amount of silicon is sufficient to give a very hot steel. On account of using a high percentage of

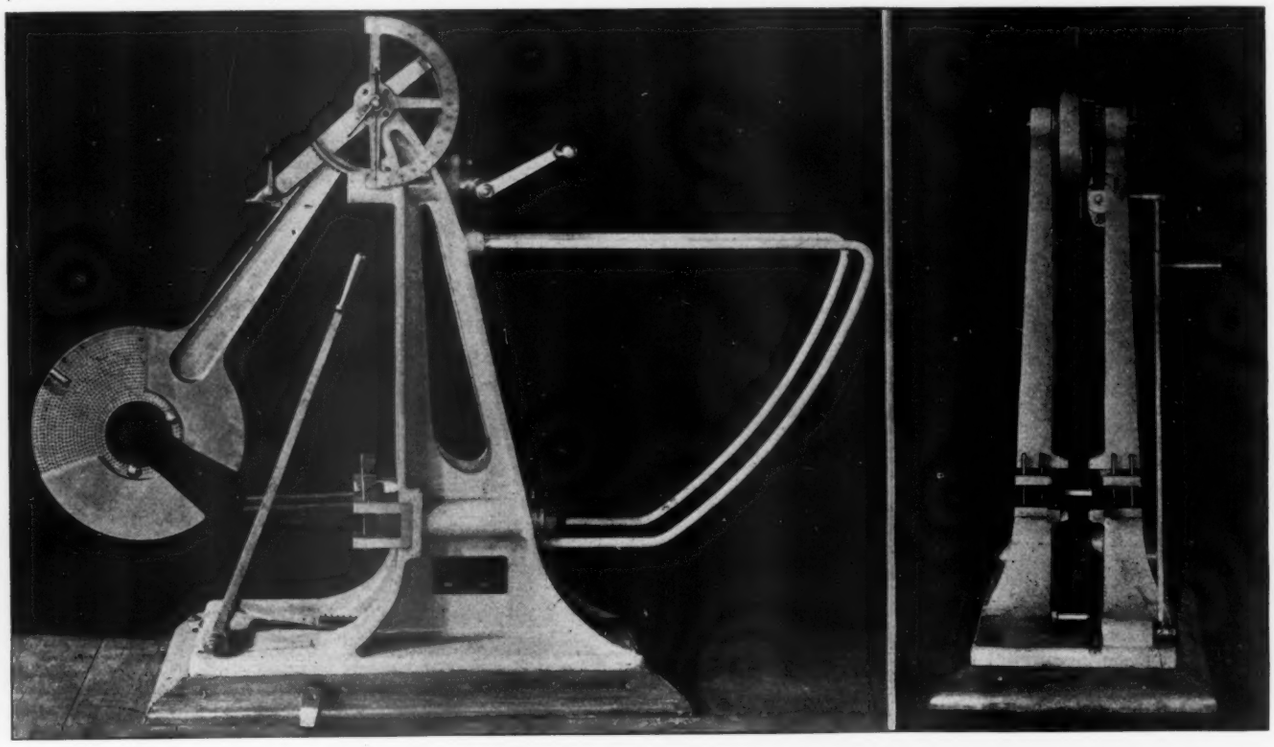


FIG. 4—SIDE VIEW OF CHARPY IMPACT MACHINE. FIG. 5—END VIEW OF CHARPY MACHINE WITH SPECIMEN IN PLACE FOR TESTING

steel scrap in the cupola charge, the percentage of carbon is cut down in the cupola metal, thereby shortening the blow in the converter. The theory which is also borne out by practice is that silicon will give the requisite amount of heat units by its combustion, whereas the combustion of the carbon, which results in the formation of carbon monoxide, gives off very little heat, barely sufficient to counteract the chilling effect of the nitrogen introduced with the blast and the radiation and conduction losses.

In blowing, a pressure of 4½ to 5½ pounds is maintained. The carbon flame is obtained usually about two to three minutes after the beginning of the blow, the total time per blow being 16 to 17 minutes.

Sometimes, due to carelessness upon the part of some of the men, the ladle and converter will not be hot enough for the first blow, and this will be indicated by the appearance of the flame. The judicious use of 50 per cent ferrosilicon at this stage will usually overcome the difficulty, which, however, should not be encountered.

Additions to Converter Metal

The service demands the use of four ladles, one for the cupola, one to receive the weighed charge of molten cupola iron, transferring it to converter, and two ladles used for pouring the castings. They are all lip-poured ladles, operated with worm-gearing, a bottom poured ladle being occasionally used for particular work. While one heat is being poured in the molds, the other casting ladle with the necessary amounts of ferromanganese, ferrosilicon and ferrotitanium in the bottom is being preheated under an oil-fired ladle heater.

About two minutes before the finish of the blow, the ladle is lowered on the platform scale, tared, and scale weights set for necessary addition of molten cupola iron used for recarbonizing. This amount of cupola metal for recarbonizing will vary according to the size of the charge entering the converter, the calculated losses in the converter and the desired final carbon. It is found that, ordinarily, one can estimate the losses in the converter quite closely, and thus vary the amount of cupola metal accordingly, but in cases of doubt, it is the practice to weigh the blown metal poured into the molten cupola iron. The regular practice, however, is as follows: After the necessary cupola metal has been added to the ladle, the crane swings this ladle over to the converter and the blown metal is emptied into the ladle. As soon as the vessel is turned down at the end of the blow, the vesselmen throws a couple of shovels full of dry sand on top of the slag in the vessel and then throws a brick on top of the slag just inside the nose of the vessel. When pouring the blown metal from the vessel into the ladle, the vesselman, by means of a long bar or rod resting on this brick, retains nearly all of the slag in the vessel, which slag is removed by turning the vessel upside down as soon as the ladle is swung out of the pit. The casting ladle is taken to the skimming floor, and there, by means of bent hooks, the small amount of slag is removed from the top of the steel. The steel should be hot enough at this stage to be able to hold it at least 10 minutes before starting to pour. Just before starting to pour the first mold, the thin film of slag adjacent to the lip is skimmed back, and a hot brick dropped on top of the steel, next to the lip. When pouring into the molds, a man keeps this skimming brick in place (close to the ladle lip), in this way effectually holding back the remaining blanket of slag.

In concluding the remarks concerning the converter practice, it may be well to emphasize a few points which may possibly not have been duly accentuated above:

1.—Careful selection and grading of melting stocks.
2.—Small cupola charges, thus obtaining uniform melting practice and uniform iron.
3.—Sufficient preheating of ladles and converter.
4.—Hot, quick blows.
5.—Careful skimming in converter and ladle
6.—Holding the steel in the ladle at least 10 minutes prior to pouring.
7.—The most important requisite of all, hot steel.

Open-Hearth Furnace

The open-hearth furnace used is, as previously stated, a 15-ton tilting furnace especially adapted for burning oil. It has but one set of checker chambers and one reversing valve. The size of the hearth is 20 x 9 feet.

The common practice in making the acid bottom is departed from somewhat inasmuch as an average of only four to six inches of bottoming sand is used. The remainder of the bottom and banks is built up of silica brick, with careful allowance made in the laying for expansion of each successive course. It is found that by making the bottom in this manner, much less trouble is experienced due to corrosive action of the slag or from excessive rust on steel scrap.

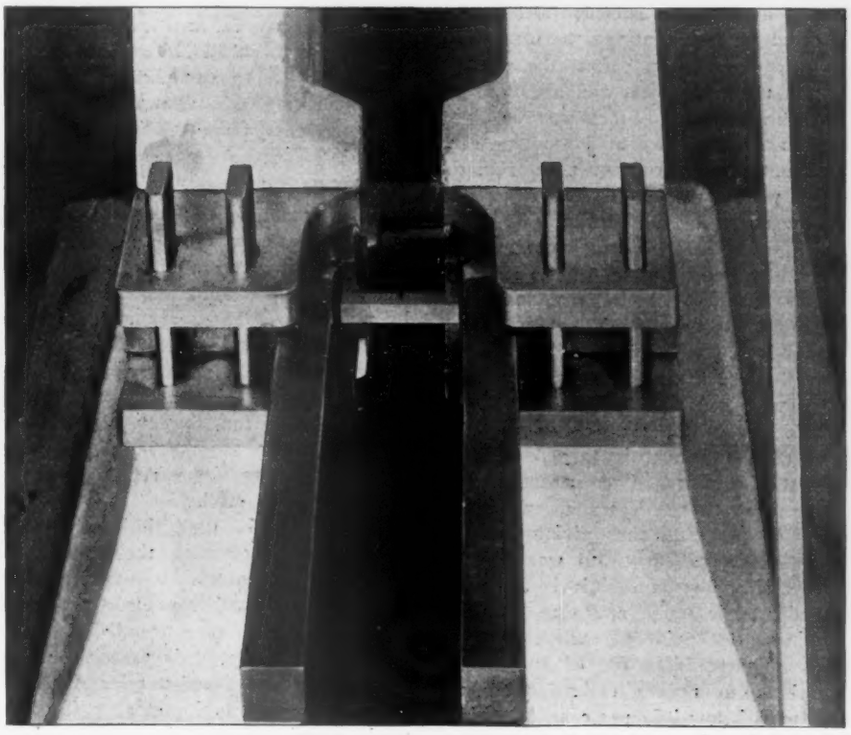


FIG. 6—DETAIL OF SPECIMEN HOLDER

The purchased materials used in making up the open-hearth charges include pig iron with silicon, 1.50 to 2.25 per cent; manganese, maximum, 1.50 per cent; sulphur and phosphorus, not over 0.035 per cent Plate scrap and crop ends of suitable size and shape with sulphur and phosphorus not over 0.04 per cent also are employed. An important reason for the low-sulphur specifications in case of crop ends, is because this material is used in the cupola charge for converter steel, as previously described. Other materials used are shop scrap; risers; gates, etc.; ferrosili-

con, ordinary 50 per cent grade; ferromanganese, 80 per cent grade; ferrotitanium, 15 to 18 per cent titanium content, 5 to 8 per cent carbon content; aluminum, the best grade and also No. 2 aluminum running 94 to 96 per cent. The following is a typical charge: Pig iron, 7000 pounds; shop scrap, 10,000 pounds; plate scrap, 5000 pounds; crop ends, 14,000 pounds. This will give a charge of approximately the following composition: Carbon, 1 per cent; manganese, 0.69 per cent; silicon, 0.60 per cent.

Order of Charging

First pig iron, next plate scrap and third heavy scrap are charged in the order named. A sufficient interval is allowed between charging the plate scrap and heavy scrap to permit the plate to soften under the heat and sag down in the furnace. It is then covered with one to 1½ barrows of bottoming sand to counteract the consequences from the rust, which results in excessive corrosive action on the banks.

A good flame during charging is maintained and to completely melt requires about 4½ hours from the time charging is begun. The furnace is charged by hand, requiring about seven men, besides the first helper. The time consumed averages about 1½ to 2 hours. From the time charging is begun until the heat is tapped averages almost six hours. The carbon in the bath, when charge is melted, will average 0.65 per cent, thus giving from 28 to 30 points of carbon to work on before adding the finals. It is attempted to adjust the flame and slag so as to eliminate one point of carbon in about three minutes. The use of iron ore in the bath to reduce carbon, after the carbon is below 0.55 per cent, is avoided if possible. In case the bath is lying too quiet and carbon not dropping fast enough, 100 to 200 pounds of crop ends are thrown in without increasing the basicity of the slag. The condition of the slag in the furnace and its character when poured into test molds for fracture tests are carefully observed. If it has the least indication of wildness and especially if the end of the heat is near, it is adjusted effectively by the addition of bottoming sand and a little loam, otherwise "blowy" castings will be the consequence.

The latter part of the refining operation is done entirely by heat, making the steel very hot and the slag as gray as possible, with a reduction of some of the silica in the slag to silicon. This reduction of silica will have to be estimated by the appearance of the test specimen and when the steel is hot enough and the carbon at about 0.38 per cent there is introduced enough ferrosilicon to give about 0.25 to 0.30 per cent silicon, the gas and air are shut off and damper lowered until carbon report is received from chemical laboratory. The ferromanganese is then added, stirring it through the bath as quickly as possible, and in from three to four minutes the heat is tapped out.

A pouring cup and runner large enough to take a full stream of metal without choking back is used in pouring all castings. Risers and gate openings are kept closed until just before pouring to prevent any dirt or foreign matter finding its way into the mold.

In making No. 3 cast steel, the attempt is made to tap at about 0.38 per cent carbon which, with the carbon taken up from the ferromanganese addition, will give a final carbon of 0.43 per cent in the heat. In other words, it is endeavored to catch carbon coming down, making due allowance for carbon increment from the ferroalloy additions.

In adding the finals there is used a variable amount of ferrosilicon, 350 pounds of ferromanganese, and 90 to 100 pounds of ferrotitanium. Sometimes a portion of ferrotitanium is replaced by aluminum. These are added to the ladle during tapping out. In tapping a heat, pieces of sacks or a piece of wood block is held in the tap hole sufficiently long for the metal bath to entirely include the tap hole, thus preventing the slag from running out in advance of the steel.

Great care is used in making up stoppers and adjusting the stopper in the ladle. A nozzle is used that is double burned and very true to shape and of a size recommended by the American Foundrymen's association for the 2-inch round faced nozzle. A standard grade of graphite stopper head is used, suitable for this nozzle. The stopper-head is keyed to the stopper-rod, being keyed up snugly and then released just a little. The stopper rod is 1¾ inches in diameter, made up with 2-inch sleeves.

Annealing

The paragraphs in the specifications governing the annealing of castings are as follows:

"All castings shall be heated at least once to a temperature not less than 30 degrees Cent. above the AC_3 point. If the castings are then allowed to cool in the furnace, no reheating shall be necessary, but if they are drawn from the furnace and air chilled they shall be reheated to a suitable temperature. Rapid cooling as in oil or water will not be permitted without special authority.

"All forgings and castings shall be heated for annealing, drawing, or other heat treatment as required as evenly as possible, and the operation shall be performed on the whole of a piece, never on a part only. During any annealing, drawing, or other heat-treating process, steel pieces should be held at the desired temperature for a sufficient length of time to insure that the heaviest part of the piece shall be thoroughly soaked at this temperature."

The furnace employed at Watertown arsenal consist of one car bottom annealing furnace, 25 x 16 x 7 feet, with track at foundry-floor level. This unit is fired from the side into a combustion chamber, with four high-pressure oil burners; the second furnace, 15 x 7 feet 10 inches x 8 feet, is also of the car-bottom type, the tracks being in a pit bringing the car bottom to the foundry level. This furnace is also fired from the side into a combustion chamber and is equipped with two high-pressure oil burners.

Platinum Couples Employed

Temperature control is maintained with platinum couples which are connected to Leeds & Northrup recorders. The couples and recorders are carefully checked each week and an accuracy of 5 degrees Cent. is maintained.

The standard annealing treatment for No. 3 steel is as follows: Heating to 950 degrees Cent., holding for four hours followed by air chilling. After the completion of the chill the castings are drawn at 500 degrees Cent. This subsequent draw is considered very essential to relieve any internal strains which might be present. This temperature, 500 degrees Cent., is not high enough, however, to produce any appreciable readjustment of structure.

All No. 2 castings are annealed by heating to 900 degrees Cent., holding at this temperature for four hours, followed by furnace cooling. The work is very frequently going through the foundry in such a manner that it is not feasible to separate the No. 3 and No. 2 for the annealing operation. In this case, No. 2 is given the No. 3 treatment, namely, the air chill and draw.

The specifications state that rapid cooling such as water or oil will not be permitted without special authority. This clause appears to be justifiable. To allow promiscuous quenching operations to be carried out on all classes of work without knowing the equipment of the contracting parties might lead to serious trouble. Coupons representing small work might be satisfactorily quenched whereas the castings represented thereby might not be quenched in a satisfactory manner. Furthermore, the dangers of cracking are always present and it would seem essential for the government to know not only the facilities but also the experience of the contractor in conducting this class of treatment before permis-

sion could be granted to heat treat in this manner.

The principal special treatment which is sometimes employed at Watertown arsenal consists in a prolonged anneal, six to eight hours on small sections, just above the AC_3 point; this treatment has often been successful in improving the ductility of heats which have been given the standard No. 2 or No. 3 treatment. In fact, it is never used unless the standard treatment has failed to produce the desired results and in accordance with specifications, could not be given unless the castings had previously been annealed at a higher temperature.

Recourse is also had at times, in the case of some alloy castings, to a treatment similar to the standard No. 3. The first operation consists of an air chill from 1050 degrees Cent. followed by a draw at approximately 775 degrees Cent.

In certain exceptional cases either water or oil quenching from temperature ranging from 800 degrees to 900 degrees, followed by drawing, at temperatures from 600 to 700 degrees, has been resorted to.

The following figures taken from the results of tests on heats cast in April, May or June may be of some interest:

Month	No. of casting heats converter	Per cent passing 1st test	No. of heats cast O. H.	Per cent passing 1st test
April	32	86	8	87½
May	50	60	11	90
June	55	80	10	80

The per cent of heats passing the first test in May from the converter steel was lower than usual. This was due to the fact that a number of alloy steel heats were made which did not comply with the specifications after the first treatment. This specification was 55,000 pounds elastic limit, 90,000 pounds tensile strength, 15 per cent elongation and 25 per cent contraction.

In compiling the above table only those heats, all the castings of which passed the first test, were counted. If a second test was necessary, although due to a defective first specimen, the heat was considered as not passing the first test.

When a heat fails to pass the first test it is the duty of the laboratory to check the chemical analysis, make a microscopic examination of the specimens which failed and then recommend a second treatment. If, for example, the first test showed the following results: 48,000 pounds elastic limit; 90,000 pounds tensile strength; 11 per cent elongation and 14.5 per cent contraction; the second treatment would probably consist of a long anneal just above the critical range followed by furnace cooling. If the low ductility previously mentioned was due to too high carbon, which can easily be determined by laboratory examination, the second treatment would in all probability reduce the elastic limit and tensile strength increasing at the same time the ductility.

If the elastic limit and tensile strength were low on the first test while the ductility was high, the heat would probably be again air chilled but additional care taken in arranging the castings on the car so as to insure their receiving a good circulation of air when pulled from the furnace.

In meeting the prescribed physical requirements, one particular type of difficulty is often encountered to which special emphasis should be given. The following illustrations will bring out this point: Fig. 1 shows the microstructure of a specimen of cast steel at 50 and 500 diameters, respectively. This material represents the attempt of a commercial foundry to meet the government specifications for cast steel No. 3. It will be noted that this material is deficient in ductility. Attention is also invited to Fig. 2. Here again the chemical composition, elastic limit and tensile strength are satisfactory but the elongation and contraction are very poor. Fig. 3 shows a specimen which was entirely satisfactory.

The explanation of the difference in behavior of these different heats under test is quite simple but it is beyond the scope of present methods in chemical analysis. Microscopic examination shows that both the heats failing in ductility are contaminated with a great deal of slag.

Attention is again invited to Figs. 1 and 2. The micrographs at 500 diameters show an almost complete slag network which surrounded the original austentite grains. This network is very effective in preventing the development of proper structure by annealing and, furthermore, produces decided cold shortness and lack of ductility.

The specimen shown in Fig. 3, although far from being as free from slag as might be desired, shows a much better structure. A continuous slag network is absent and hence the better ductility. The specimens shown in Figs. 1 and 2 were undoubtedly poured from cold steel. The slag particles present in the bath at the conclusion of the blow were effectively trapped. This, as mentioned above, is due to cold metal, the slag particles not having opportunity by virtue of their specific gravity to rise to the surface.

Fig. 3 shows a specimen having a decidedly better structure with regard to slag. This test was poured from a hotter blow than either Fig. 1 or Fig. 2. The slag particles have coalesced and the network is destroyed. If this metal had been still hotter, these coalesced particles would not have been trapped.

Although the foregoing may be regarded as a hypothesis having no place in an ordinary steel foundry, it is felt that enough evidence has been gathered to remove it from the realms of theory to the domain of facts.

It might be well before passing from this portion of the discussion to state that when a specimen fails to pass the requirements of ductility and has a structure similar to Figs. 1 and 2, further annealing treatment is considered useless. The trouble is cold metal. Annealing medicine cannot cure such a disorder and the patient is doomed.

Investigations of difficulties are constantly being made and, at the present time, every effort is being put forth to improve the product of the foundry. One of the tests which has been and is now useful in this respect is described below for the benefit of those who are not familiar with it.

Fig. 4 shows a side view of the Charpy impact machine and Figs. 5 and 6 end views of the same instrument with the specimen in place for testing. This illustration also shows the form of a specimen used. In operation, the pendulum is elevated to a fixed height and then released. The specimen is struck a sharp blow and depending upon the amount of work absorbed by the specimen, the pendulum is retarded by a certain amount which is determined by the excess angle. The foot pounds absorbed by rupture can then easily be computed.

It is the practice to record this as foot pounds absorbed per square inch, using the data obtained from the small specimen in the same manner as computing the results from a standard tensile specimen. This is not rigidly true as the results obtained from different size notched specimens subjected to shock do not follow the simple laws of similarity which hold for tensile specimens. However, this method gives the significance of comparative figures which are understood by all concerned.

The following experiment serves to illustrate the effect of varying heat treatments upon the shock strength of plain cast steel of approximately 0.30 per cent carbon and 0.62 per cent manganese. After being annealed at 900 degrees Cent. for two hours, water quenched and drawn at 650 degrees Cent., an average of seven specimens showed 185 foot pounds absorbed per square inch. After being annealed at 850 degrees Cent. for two hours, air chilled and drawn at 500 degrees Cent. for two hours, an average of eight specimens showed 153 foot pounds absorbed per square inch. After being annealed at 900 degrees Cent. for two hours and furnace cooled, an average

of eight specimens showed 146 foot pounds absorbed per square inch. It will be noted from these results that the water-quenched and drawn casting is superior to any other treatments as far as shock is concerned. The air-chilled casting is also superior to the furnace cooled.

Many experiments such as these are being conducted and as previously stated in this paper, it is thought that ultimately high-grade alloy castings will replace many parts now being made of forgings. Although the very term casting brings up unpleasant thoughts in the minds of many designers, it cannot be disputed that by the very nature of the method of manufacture, a casting has one decided advantage over a forging. This advantage lies in the fact that the physical properties of a casting are the same in all planes if the annealing and casting operations have been properly carried out. It is a matter of common knowledge that the physical properties of a forging are widely different in different planes. In some exaggerated cases, the elongation may be 22 per cent in one plane whereas it is practically zero in a plane at right angles. As long as suddenly applied stresses are confined to the plane having good ductility, failure will not ensue, but if by any chance they occur in the planes having poor ductility, failure is almost certain. The static test comes far from telling all of the truth, especially when the specimens are taken in one direction only. The Charpy impact test will pick out these cases of absence of ductility in certain planes and it is for this reason that its use has been successful.

In view of results obtained on the Charpy impact machine, investigation at the Watertown arsenal leads to considerable optimism in the eventual replacement of many high grade forgings with castings. Furthermore, this replacement will result in considerable saving of time and money, when such castings can be produced on a commercial basis.

Scrap Nickel Anodes Reclaimed by Welding

The practice of utilizing every pound of nickel anodes for service by welding the scraps together is saving considerable money in many plating departments and establishments. Until recent years, many firms sold their worn anodes as scrap for want of a thoroughly satisfactory method of utilizing them. This was always a source of considerable loss to platers for the scraps often represent a considerable portion of the original anodes and their junk value is less than one-half their original cost. By welding the scraps together by the oxy-acetylene process, every pound of the costly metal is utilized for plating purposes at a trifling welding cost.

The practice of welding scrap anodes usually is as follows: The worn anodes, as they are withdrawn from the tanks, are turned over to some workman who handles the welding. A scrap of suitable size and shape is selected as a hanger and other scraps are tacked to it by welding until the desired size and weight are secured. The tacking consists of melting the scraps, at the point of welding, by the heat of the oxy-acetylene flame, allowing them to run together or fuse into one piece. The tacking of a joint requires but a moment as the temperature of the oxy-acetylene flame, which is approximately 6300 degrees Fahr. causes the metal to fuse quickly.

No flux is used as the metal runs together and where necessary another piece of scrap nickel is used as a filling rod.

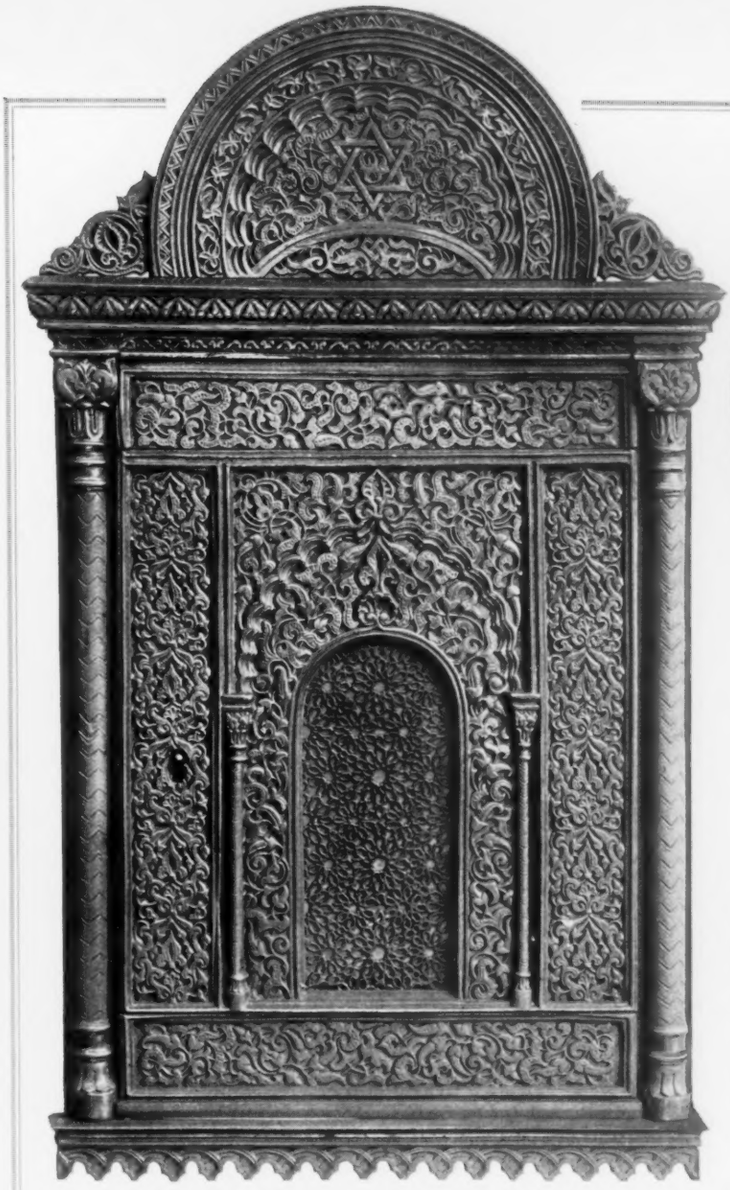
The oxy-acetylene flame is also used to remove the brass hooks from the scraps, the solder melting rapidly, leaving the pure anode to be welded.

WELDING SCRAP ANODES BY OXY-ACETYLENE METHOD

Several other methods of utilizing scrap anodes have been tried, but with uncertain results. The method of fastening them together with rivets and similar methods are seldom thoroughly dependable because of uncertain conductivity. It is impracticable for anyone but the manufacturer to re-melt and re-pour anodes because in so doing the composition is changed. A decided advantage in welding the scraps together is that the original composition is not changed and the fused joints insure conductivity equal to that of new anodes. Another advantage is that no skill or experience in the art of welding is required to weld scrap nickel anodes. The accompanying illustration shows the welding of scrap anodes by the Prest-O-Lite process of oxy-acetylene welding. Welded anodes are shown in the foreground.

In these days of high nickel prices and an impending shortage, the reclamation of scrap anodes at such a trifling cost will appeal to those alert for possibilities in keeping down manufacturing costs.

The Macleod Co., Cincinnati, manufacturer of sandblast equipment, metal melting furnaces and other foundry accessories and supplies, has completed extensive additions to its plants and recently has increased its capital to $100,000. This company has been established for more than 20 years and has built up a large trade in foundry equipment of all kinds.



In appearance, this view of a gray iron reproduction closely resembles the finest of hand wrought craft work—The original is modeled after a cloister door in a southern German cathedral

Unique Gray Iron Castings

German Foundrymen Skillfully Reproduce Artistic Gold and Silver Craft Work

IRON is seldom associated with gold, silver or even the more common metals such as copper and bronze as a medium for the skilled artisan to express his creative genius in definite form. The illustrations on this and the following page, however, show what may be done with this utilitarian metal when it is handled by skilled foundrymen. The castings illustrated are reproductions made of high phosphorus iron by German molders. Although most of the pieces are not of original design, the craftsmanship shows unusual technique of execution. The German artisan is a clever imitator, but he lacks the true artistic sense. He has an eye for bold and striking decorative effects but fails to appreciate the value of contrast. The castings are part of a collection of imported art pieces owned by John A. Penton, of Cleveland.

Plaques of characteristic Teutonic design

Although made of gray iron, the art work on this jewel box is as prominent as on the handmade gold case

Filigree clock hand—Its weight is practically nil

The two plaques are typically Teutonic is design—It will be noted that the central figures on the two are identical—Historical epics are represented by the single characters and groups—The figures around the borders illustrating warriors of old are particularly interesting because they indicate the influence of centuries of conquest upon the German artist

Pulverized Coal For Melting Malleable Iron

Comprehensive Tests Reveal a Number of Important Advantages for Powdered Fuel—Hand Firing and Mechanical Stokers Not Satisfactory

By W R Bean

THE need for some improved method of firing air furnaces used in melting malleable iron which will be less laborious and more dependable than the present method of hand firing will be readily acknowledged by many who have had experience in this direction. While more is known today than in past years regarding the way in which hand firing of the malleable melting furnace should be done, it is questionable if there has been any decided improvement in the results obtained, due to the class of labor on which it is necessary to depend for work of this character.

Aside from the limited use of the open-hearth furnace in melting malleable iron; a very small number of furnaces fired with oil or natural gas; and the recent application of the electric furnace as a unit in the melting and refining process; the use of which, however, will no doubt be confined for some time to come largely to new foundry plants, we are dependent upon gas coal as the fuel for melting malleable iron, the firing of which may be accomplished by hand, by mechanical stoker and by introducing coal in pulverized form.

Hand Firing Cannot Be Uniform

The essential factor in the burning of any fuel is the proper proportioning of air to the combustible available for burning at a given time. It is obvious that with hand firing there can be no uniformity in this essential feature because the amount and size of the combustible available is constantly varying. When coal is thrown on a hot fire bed, the volatile products are rapidly driven off with the result that there is not sufficient oxygen present for complete combustion, the supply of air being constant, or if there is sufficient for this condition there must of necessity be an excess as the coal burns down between firing periods.

The mechanical stoker has been tried out on the air furnace many times, but in only a few instances has the equipment installed remained in service for any considerable period. At present I do not know of any air furnaces, melting malleable iron, which are being fired with a modern type mechanical stoker, although in one plant there are several furnaces used for melting cast iron for special purposes, which are being successfully fired with mechanical stokers of the underfeed type.

The figures on pulverized coal firing, included in the accompanying table, cover a number of heats melted with pulverized coal in a furnace at the Deering works of the International Harvester Co., Chicago. Thirty-six heats in all were taken, as will be seen by reference to the tabulated results. These were not sufficient to determine either the practicability or impracticability of the method, but the results obtained appeal to me as having sufficient merit to justify some progressive organization in carrying the matter further, especially in plants where pulverized coal is now being used for annealing purposes.

Fundamental to success in the operation is the kind of fuel used and this cannot be very different than that which it has been found necessary to use for best results in hand firing. Coal high in volatile combustible matter—30 per cent or over—is very desirable and the ash content should be below 10 per cent and the sulphur below 1.5 per cent. However, slack coal from the screened coal generally used for hand firing air furnaces can be satisfactorily employed, the principal objection being the higher ash and sulphur content.

Just how detrimental the deposit of ash over the charge before melting down and over the bath after melting will be, is a question that is yet to be determined. With a suitable combustion chamber and burner this probably would not cause serious trouble. However, there is a considerable total quantity in the fuel to be cared for. For example, in a 20-ton heat, assuming 800 pounds of coal per ton of iron and 10 per cent ash, there would be 1600 pounds of ash to dispose of and it is a matter of importance as to where this is deposited. Obviously it is advantageous to deposit it as much as possible in the combustion chamber and with a view to readily disposing of this deposit, one company in the pulverized coal equipment business has developed a combination of low-pressure feeder, burner and combustion chamber, whereby the majority of the noncombustible is precipitated before the heating zone of the furnace is reached. The point of deposit of ash is dependent upon a number of factors among which are fineness of coal, point and completion of combustion, and velocity resulting from draft or pressure.

There is one point of importance in which the coal may to advantage be different from that used for hand firing, namely, that coal in which the fusing point of the ash is low has certain advantages over coal in which the ash has a high fusing point. Ash with a low fusing point will deposit earlier as slag. This is particularly advantageous for plants located in the west or middle west where the coal available at lowest cost generally has ash of a low fusing point, although otherwise suitable for melting furnace firing by hand. In the matter of sulphur content of coal I have been unable to find any difference in the effect of this element on the metal between one method of firing and another, since it volatilizes in any case and passes over the bath with the products of combustion.

The Degree of Pulverizing

For quick combustion and high temperature, coal should be pulverized to a fineness of not less than 85 per cent of the total through 200 mesh and 95 per cent of the total through 100 mesh. Some operators found it advisable in open-hearth practice to pulverize to an even higher degree of fineness. The advantage to be gained from this will be found to exist equally with the air furnace and the open-hearth furnace, since high temperature is the end sought in both cases. Coal for pulverizing must be thoroughly dry, 1 per cent or under in moisture and preferably as low as 0.50 per cent. This is necessary not alone for the proper mixing and burning of the fuel, but from the standpoint of cost of pulverizing. The cost of pulverizing is a variable factor in which many different elements, particularly the cost of power, are involved and can only be stated definitely under known conditions. Some large plants are pulverizing at a cost

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The author of this paper, which was presented at the Boston meeting of the American Foundrymen's Association, is metallurgist, Naugatuck Malleable Iron Works, Naugatuck, Conn.

of approximately 25 cents for each ton.

The furnace on which the experiments were conducted was of good general design with stack of ample proportion. In making the change from hand firing to pulverized coal firing only minor alterations were required. The fire-box was converted to a combustion chamber by increasing the length to give sufficient travel of the coal and air mixture to get good ignition before impingement of the flame against bridge wall, which was allowed to remain as in hand-fired practice. The grates were covered over with about 6 inches of cinders to form a hearth for deposit of the slag from the ash in the fuel. The length of the melting chamber from bridge wall to bridge wall was 24¾ feet, and the furnace was 7 feet wide at the front. The side walls were parallel for 11 feet back of the front bridge wall, from which point the furnace narrowed to 5½ feet at the rear flue or neck, the opening through which was approximately 420 square inches in area. The area of stack inside of lining was 1385 square inches.

Pulverized coal fires, with coal of proper dryness, fineness and volatile content, are very readily started, it only being necessary to light a small quantity of oily waste in front of a burner and start the coal and air feeds. With any reasonable amount of care, there need be no smoke or coke formed where there is sufficient flame-way in starting up a malleable melting furnace and, of course, there is none after the furnace and charge become hot. To prevent smoke and coke in starting, it is necessary to burn with a short flame and get complete combustion in the front of the furnace.

It will be well to have clearly in mind the distinction between a pulverized coal burner and a pulverized coal feeder or controller. The function of the latter is to supply uniformly to the burner the quantity of coal which it may be desirable or necessary to burn to produce the required temperature. The mixture of coal and air takes place in the burner, combustion beginning soon after this mixture enters the combustion chamber, the exact point at which this takes place being dependent upon velocity, air proportion and other factors.

Turning now to the figures in the table at the end of this paper, we find results, in coal consumption per ton of iron, melting time and silicon loss, all the way from poor to exceptionally good, the latter applying particularly to heats Nos. 34 and 35. There are 12 different furnace arrangements indicated under the heading, "Furnace Arrangement". In some cases the change between one arrangement and another was only slight, yet it was considered of sufficient importance to record; in other cases the change was a radical one.

Furnace arrangement No. 11 produced the best results, the figures for heats Nos. 34 and 35 comparing favorably with the very best practice under hand firing methods. The change from arrangement No. 10 to arrangement No. 11 did not in any way involve the coal feeding or burning equipment, but was one of furnace construction. It consisted of lowering the roof of the furnace so as to bring the nozzle outlet of the top blast into the proper relation with the bath and directing this in such a way as would bring the point of highest temperature in direct contact with the metal and in providing sufficient volume of air through the top blast.

In judging the coal consumption figures it should be remembered that many of the heats were single heats only, taken after the furnace had been idle for days or for weeks and that a large amount of fuel was required to bring the furnace up to the temperature that would exist in a furnace in regular operation for one or two heats a day.

Troubles During Hot Months

The period which is of greatest interest because of the more nearly continuous operation is that from July 15 to 31 inclusive with furnace arrangement Nos. 10 and 11, heats 20 to 35, inclusive. During this period we tried to get the proper proportion of air and fuel and in this we were only partly successful because arrangement could not be made to continue the test for a period sufficiently long to work the matter out to a final conclusion. There was, during this time, a fairly regular decrease in coal per ton of iron melted, in time per ton melted, and in silicon loss from oxidation during the heat. The relation between coal per ton and silicon loss is of particular interest. In looking over these figures in light of more recent experience, it is evident that the high coal consumption was largely the result of excess air, although there was not much difference in the operation under furnace arrangement Nos. 10 and 11.

Heats Nos. 1 to 35, inclusive, were taken with all of the air for combustion supplied under pressure. Heat No. 36 was taken with something more than half the air taken in by induction, only the top blast and the air necessary to convey the coal into the burner being supplied under pressure. Not much can be based on the results of a single heat, but from what has been accomplished in locomotive and stationary boiler firing

Results of Tests With Pulverized Coal

Heat No.	Date 1914	Charge, pounds	Coal per ton of iron, pounds	Duration of heat, hr.	Duration of heat, min.	Time per ton melted, min.	Silicon loss, per cent	Furnace arrangement, No.	Condition of furnace
1	Mar. 28	12,000	.....	5	6	50	....	1	Cold
2	Mar. 30	12,000	.....	7	15	71	....	2	Cold
3	Apr. 4	12,000	1,120	4	15	42	0.51	3	Cold
4	Apr. 6	20,000	1,536	8	15	49	0.58	3	Cold
5	Apr. 7	20,000	1,198	..	..	..	0.44	3	Cold
6	Apr. 8	20,000	1,192	7	25	44	0.43	3	Cold
7	Apr. 8	20,340	874	5	40	33	0.15	3	Hot
8	May 18	20,000	1,066	9	0	54	0.49	4	Cold
9	May 20	20,000	1,134	7	30	45	0.51	4	Cold
10	May 21	23,000	1,508	..	..	..	0.48	4	Cold
11	June 8	20,300	1,536	9	55	57	1.15	5	Cold
12	June 9	20,350	1,198	9	0	52	1.21	5	Cold
13	June 10	20,000	1,368	8	30	51	0.92	5	Cold
14	June 12	20,210	1,324	8	30	50	0.32	6	Cold
15	June 16	20,000	1,754	9	15	55	0.51	7	Cold
16	June 19	20,145	1,558	7	15	42	0.31	8	Cold
17	June 22	20,000	1,216	6	30	39	0.34	9	Cold
18	June 23	20,000	1,346	..	..	..	0.49	9	Cold
19	*June 24	20,000	1,346	..	..	..	0.58	9	Cold
20	July 15	20,000	1,696	9	15	55	0.83	10	Cold
21	July 16	20,000	1,682	7	0	42	0.87	10	Cold
22	July 17	20,300	1,056	5	30	32	0.41	10	Cold
23	July 20	20,000	1,140	6	13	37	0.48	10	Cold
24	July 20	20,340	794	4	52	28	0.39	10	Hot
25	July 21	20,760	1,250	6	0	36	0.44	10	Cold
26	July 21	24,610	822	4	43	23	0.34	10	Hot
27	July 22	20,000	970	5	0	30	0.24	10	Cold
28	*July 22	20,000	970	4	15	25	0.30	10	Hot
29	July 23	20,000	1,056	5	15	31	0.42	10	Cold
30	July 23	20,000	966	3	50	23	0.47	10	Hot
31	July 27	20,200	1,322	6	34	39	0.80	10	Cold
32	July 28	30,000	1,124	8	17	31	0.66	10	Cold
33	July 30	20,000	922	4	20	26	0.46	11	Cold
34	July 31	24,500	760	4	40	22	0.43	11	Cold
35	July 31	24,000	620	3	37	18	0.26	11	Hot
36	Aug. 4	20,000	800	4	10	25	0.43	12	Cold

*Indicates coal weights were not separated between heats Nos. 18 and 19 and Nos. 27 and 28.

under the induced draft system, I consider this method for air furnace operation one well worth considering.

The use of pulverized coal on the air furnace brings to my mind two other matters which may be well worthy of serious consideration. Waste heat boilers may be more generally employed because the method of firing lends itself readily to the maintenance of a low fire between heats to maintain the boiler capacity required in the majority of malleable foundries during the off hours of operation. Furthermore, where the steam supply is lacking, combinations of waste heat and direct firing are now being installed to provide a 150 to 200 per cent of nominal horsepower rating output, which is most advantageous in plants where power is required for other than foundry operation. There are, no doubt, some and perhaps many localities in which an agreement for exchange of power with local power distributors could be effected which would result in a material saving as compared with the present cost of air furnace melting and power supply. The other point which presents itself is the possibility of using silica brick in furnace lining, the ability to keep a furnace hot continuously making the use of this kind of brick practical.

The air furnace as at present operated is admittedly a wasteful piece of equipment, yet it lends itself better to the varying requirements of the average malleable foundry than does any other type of melting furnace and while electric melting, or more correctly perhaps, electric heating of malleable iron may make further progress, the air furnace is destined to continue to be the principal melting unit in the average mallable foundry for some years to come.

One of the achievements credited to the late David H. Browne, chief metallurgist of the International Nickel Co., is the practical application of pulverized coal firing to reverberatory smelting furnaces. I know that there are several installations in successful operation in the copper and zinc refineries and it would seem that the advantages to be gained in the malleable industry should be fully as great.

The probable or at least possible advantages to be derived from pulverized coal firing of the air furnace may be summed up as follows:

The elimination of the exhausting labor of hand firing, permitting the employment of more intelligent men in operating the furnace.

The elimination of the clinker problem which at this time is unusually serious owing to conditions existing in the coal market.

A reduction in the cost of fuel over present hand-fired practice by improved combustion, and in some cases by the use of lower-priced fuel.

The elimination of smoke.

A more advantageous use of waste-heat boilers.

A reduction in cost of furnace maintenance by the use of silica brick.

Book Review

The Principles of Iron Founding, by Richard Moldenke; cloth; 517 pages, 6 x 9 inches; published by the McGraw-Hill Book Co., Inc., and furnished by THE FOUNDRY for $4 net.

The history of iron founding is so closely bound up with that of the human race that a man need not necessarily be an iron founder to be interested in that industry. From the days of Tubal Cain, when we first find historical mention of the manufacture and use of iron, that metal has occupied a position of ever-growing importance in the life of man. Today we take its presence so much as a matter of course, that only a sudden cutting-off of the supply could make us realize how very important its use has become.

"The Principles of Iron Founding" is, therefore, a book devoted to a subject very worthy of study, both by the foundryman, who can make practical use of it, and by the layman who has a desire for knowledge for its own sake.

The opening chapter of the book traces the manufacture of iron back past its earliest recorded history into the period which, according to the author, is wrongly designated as the "bronze" age. "That the 'bronze' age is really a misnomer must be evident from the fact that the metallurgy of iron is much simpler than that of copper. Primeval man must have been aware of this situation and have used iron implements at least as early as bronze ones, if not before. The only records of these times are furnished by the content of burial places, and it would indeed be strange if on opening such mounds any iron had escaped the solvent action of the ground waters of passing ages. Hence remains of bronze alone have been discovered."

The efforts of the ancient iron masters, or "furnace men" are then described, their labors resulting now in failure and now in success. The story is told briefly but effectively, and the various threads leading through France, England, Germany, Russia, and finally this country, are followed up to the present day. Having started with Tubal Cain, we find at the end of the chapter the names of W. J. Keep, professors W. C. Unwin, F. Osmond, H. M. Howe, and A. Sauveur, and others equally familiar and important.

The historical foundation of the book laid, the author then proceeds to build the rest of the structure in logical sequence. Chapter II discusses the relation of the industry today to the other important activities of man. The good foundryman of necessity is informed about allied industries "so that he may be in a position to buy economically and timely, be able to detect inferiority in supplies bought from personal knowledge of the processes involved in their manufacture, know the problems confronting his customers, and thus be able to serve them intelligently."

In addition he must study other broader problems connected with his business. He must have some knowledge of the relation of the foundry to commerce and finance, and on interfoundry relations. He must be prepared to cope with labor problems and other questions relating to internal policy. The organization of the plant is discussed in Chapter III. The main essentials of a foundry organization are pointed out and briefly described.

The historical and economic aspects of the industry having been disposed of, the remainder of the book is devoted to the more strictly technical discussion. Chapter heading such as Outline of Iron Metallurgy; Outline of Iron-Making Processes; Properties of Cast Iron; Classification of Castings; Foundry Raw Materials; The Technology of Combustion; Melting Processes; Mixture Making, and Testing Cast Iron, give one a pretty clear idea of the field covered.

In the chapter entitled, "Outline of Iron Metallurgy", we find brief sketches showing the relation of the element iron, and its compounds to the various divisions of the iron industry, together with a discussion of the general processes involved. In Chap. V the various iron-making processes are described as are also the various types of furnace in which the processess are carried on. The properties of cast iron are covered thoroughly, 80 pages being devoted to this subject. The book is the result of years of research work, both in the foundry and the laboratory. A complete and interesting discussion of each topic treated is the result.

The Buch Foundry Equipment Co., York, Pa., in a 4-page folder illustrates and describes its line of molding machines, including the gravity type and combination jar-ramming, roll-over squeezer and pattern-drawing machine. Molding machine accessories also are included, such as floor flasks and steel flask bars, machine pattern plates, jib cranes and trolleys, cast iron ladles, bottom plates, castings, etc.

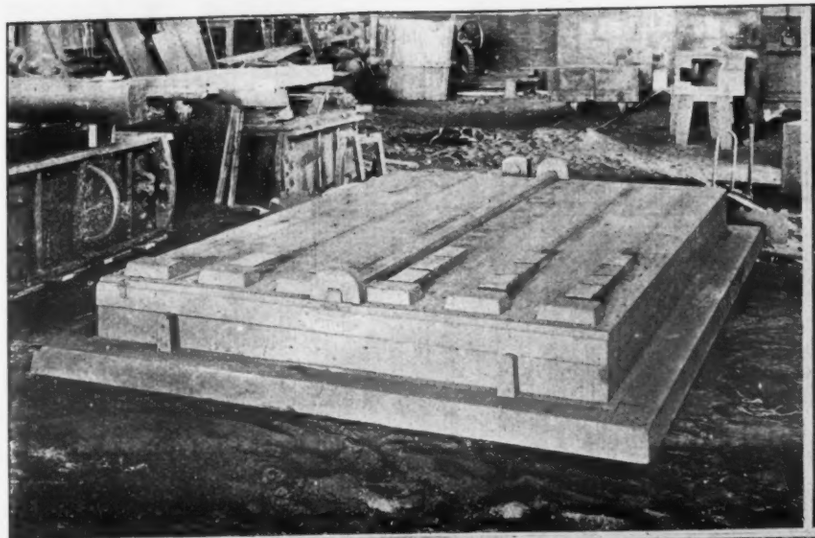


FIG. 1—FLOOR PLATE PATTERN BUILT UPON THE COVER CORE PRINTS
FIG. 3—HOW THE FLASK IS ROLLED OVER

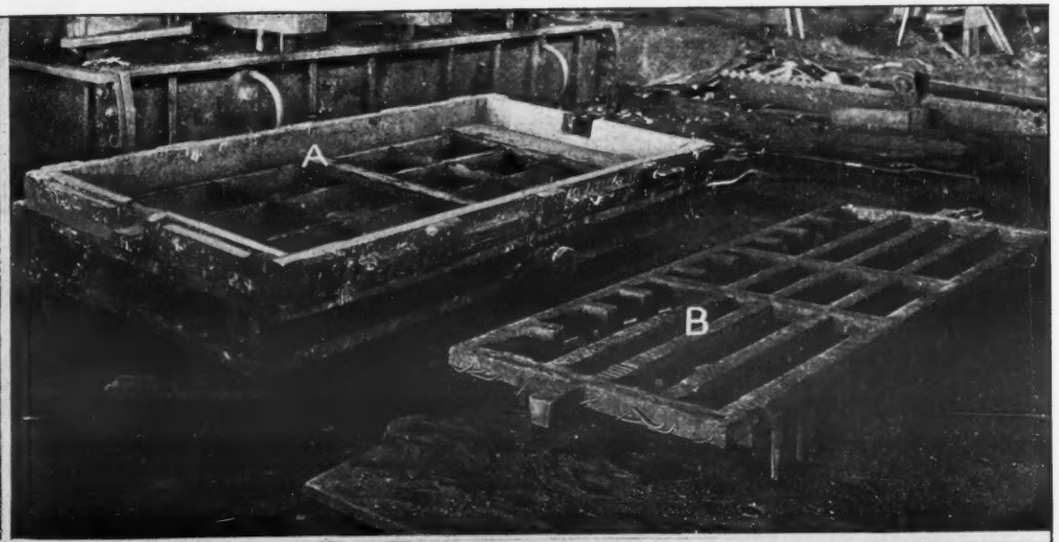
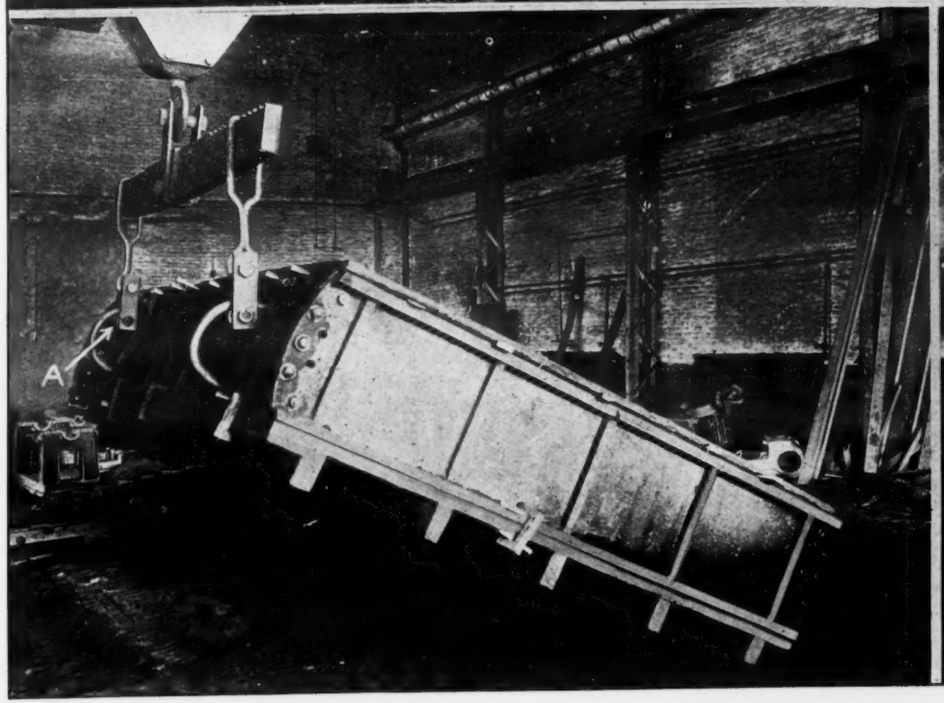
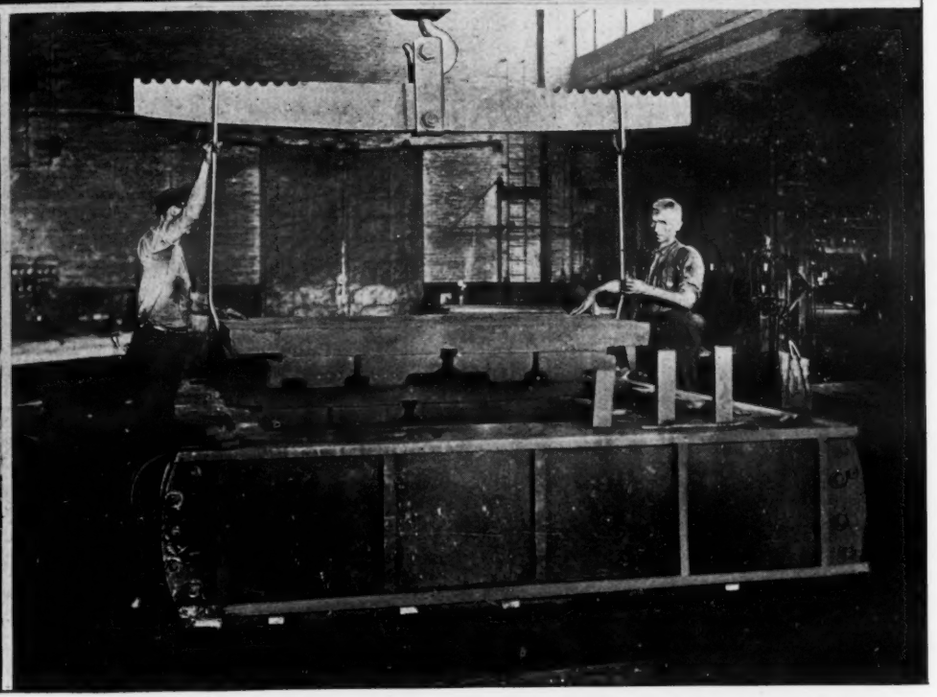


FIG. 2—THE COVER CORE BOX IS SHOWN AT *A* AND THE ARBOR AT *B*
FIG. 4—SETTING THE COVER CORES





Casting Floor Plate and Bed For a Boring Mill

How a Large Molding Job Was Successfully Handled in Spite of Unusual Restrictions—Pattern Design Simplifies Coring and Molding

By William J Kihn

IN TIMES of industrial activity the average foundry always suffers from a lack of floor space, facilities for handling materials and equipment to handle heavy work. It is also heir to the many troubles of design of castings and insufficient and unskilled help that is the lot of all foundries, whether good or bad. Consequently, it is frequently forced to depart from strictly orthodox methods of molding to accommodate purely local conditions.

This being true at the foundry of the Gurney Electric Elevator Works, Honesdale, Pa., their molding practice and methods of surmounting some of their difficulties in the production of the floor plate and traverse bed for a line of horizontal boring mills might be of interest.

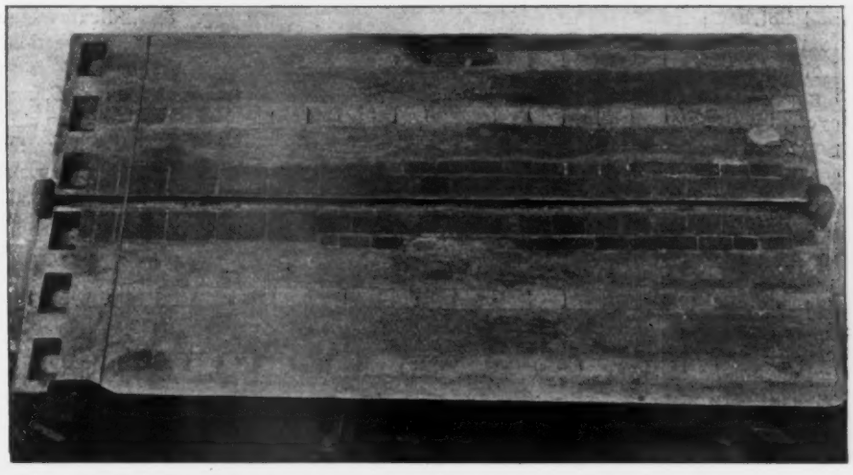


FIG. 6—FACE OF THE CASTING SHOWING THE CHILL IMPRESSIONS

FIG. 5—THE FLOOR PLATE MOLD READY TO POUR

The floor plate is 6 feet wide and varies from 9 to 12 feet in length, according to the customer's desires. The 9-foot plate weighs 10,000 pounds and the 12-foot plate, 12,500 pounds. The traverse bed is made in lengths of 10, 12 and 14 feet, weighing from 4000 to 6000 pounds.

The room necessary to roll the floor plate drag is about 15 per cent of the available molding space beneath the crane. Due to lack of room and the expensive additions necessary for mold drying ovens, all dry sand work must be skin-dried. This, together with the varying length of the castings, lack of room for ramming, rolling, drying and storing the large cope necessary for a job of this kind, led to the decision to dispense with a cope and use large cover cores.

Fig. 1 shows the pattern built upon the cover core prints, Fig. 2 is a view of the cover core box and arbor. This box makes 3-foot sections of core and as the length of the castings vary by multiples of 3 feet, any additional length of casting merely entails the lengthening of the drag and pattern, and setting additional cores.

The arbor is of simple construction and is rigid enough to last for a long time. Cores may be stocked ahead, thereby lessening the chance of loss of production through injury to any particular cores.

The actual molding af the job is relatively simple. The pattern in Fig. 1 is placed upon the heavy board, shown clamped to the drag in Fig. 3, and is carefully leveled. Chills, some of which are in position on the pattern in Fig. 1, are placed along the line of location of the T-slots desired

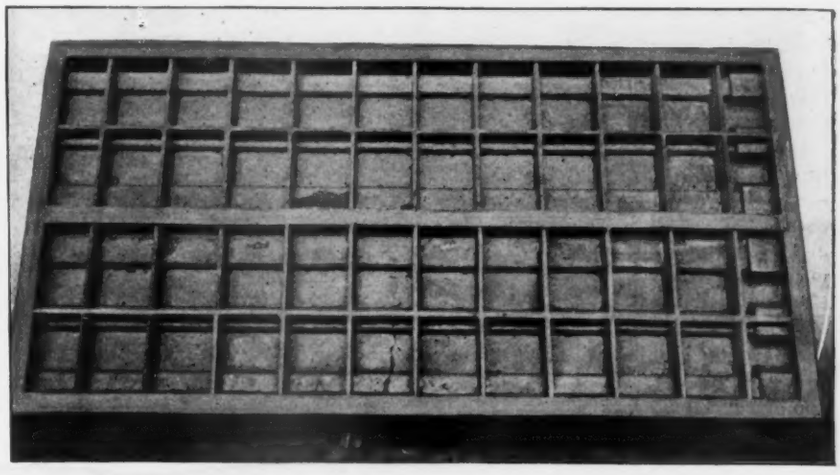


FIG. 7—REVERSE SIDE OF FLOOR PLATE CASTING, SHOWING THE CROSS RIBBING

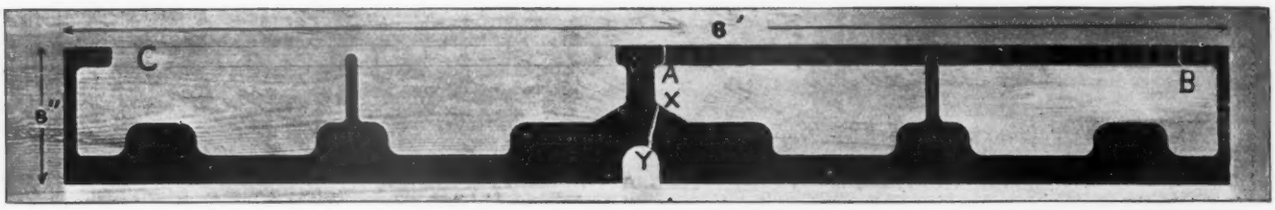


FIG. 8—PATTERNMAKER'S SECTIONAL LAYOUT OF FLOOR PLATE SHOWING UNEQUAL DISTRIBUTION OF THE METAL

in the finished casting. After ramming and bolting on the two cast iron bottom plates, the flask is ready to roll. Rolling by the usual method of hitching chains around the wrought iron eyes, however, was found to be impractical, as the slipping, and straightening-out of kinks in the chains, caused impact loads on the crane, which were above its safe working capacity.

A set of rolling slings, therefore, was devised by Thomas Fox, the foundry foreman. Each sling is composed of a grooved wheel, *A*, Fig. 3, yoked by two steel plates to a 1½-inch wrought iron sling. The slings are placed over a beam and by loosening the burrs, one of the yoke plates is dropped and the wheel is placed inside the eye. The plate is then replaced and power is applied. Since the grooved wheel rolls along the inside of the eye and as the point of concentration of the load and the center of the crane hook always lie in the same straight line, there is no appreciable friction or sudden jars to cause impact loads with consequent danger to equipment and human life.

After rolling, the pattern is drawn and the mold is finished. It is then dried over night with charcoal. The following morning the cover cores are set as shown in Fig. 4. These cores are secured by wedging them between pieces of channel iron which are laid on top of the cores and the binders which are bolted to the flask, in the manner indicated in Fig. 5.

The plate is poured from one end through six draw gates. These gates are each 3 x ⅝ inches in cross-section, the large total area of the gates being necessary in order to force the metal over the total length of the mold, the bottom of which is heavily chilled. The large amount of chills used to insure close-grained metal where the T-slots are machined and to equalize the cooling strains, is apparent from the face of the 12-foot casting, shown in Fig. 6. The illustration of the patternmaker's sectional layout, Fig. 8, indicates the tremendous variation in different sections of this casting. The line *AB* is a continuation of the inner flange, *C*, and is not strictly a part of the section. In spite of provisions to care for the strains set up by the improper distribution of metal, the first casting developed a crack at the gate end along the line *XY*. This was due, in all probability, to the quicker cooling of part of the light end walls, the light inner flange and the stresses produced by the light cross ribs which are spaced 1 foot apart for the entire length of the bed. These ribs are shown in Fig. 7, which is a view of the casting just after digging out the core. To alleviate these conditions, more chills were added along each side of the slot in the center of the casting; a curved chill, the location of which is shown on the pattern in Fig. 1, was placed in such a manner as to hasten the cooling of the metal at the point of rupture in order to strengthen it to resist the cooling stresses and, in addition, a heavy clamp was cast across the slot. This clamp is shown lying over the slot core print on each end of the pattern in Fig. 1 and has not been cut off in the illustration of the face of the casting in Fig. 6. These measures effectively stopped all cracking and marked the end of troubles with this casting.

Making the Traverse Bed

The traverse bed is another casting in which the metal distribution is very unequal, as shown by the section, Fig. 12. The variation and distribution of metal make it necessary to allow ⅜-inch rise to the center of the pattern as it lies on the board in Fig. 9. Since the pattern was built straight, two ⅜-inch pads, *A* and *B*, are placed on each end of the board on the joint line and the center of the board is clamped to the joint of the flask, and as the pattern is screwed to the board, a uniform curve is produced.

This job originally was molded with a number of cores, one lying between each set of ribs, which were spaced on one-foot centers. This involved setting 10 cores for a 10-foot bed, with spacing sticks, ramming a cope and securing them to it. The total time necessary to do this in the shop previously making these castings, was 26 hours. By combining and adding 4 inches of a cover core print to these cores, the number of cores were cut down to four, with a reduction in crane handling in the core room and foundry. Chaplets were eliminated and the molding time was cut down to 14 hours for one molder and a helper. The core time was not materially increased, the only added cost being the arbor and core material. This was a very small item compared with the saving in molding labor, however. It also permitted one casting to be made each heat, without duplicating rigging. The method of coring-up is shown in Fig. 10 and the ease with which it is done is apparent. The casting is poured from one end with four draw gates. The metal runs over a heavily chilled bottom the same as in the floor plate. The marks of the chills are clearly seen in Fig. 11, which is a view of the casting after cleaning. One point of interest is the decrease in hardness of the bed from the gate to the opposite end. Careful tests with a scleroscope indicate an average decrease of two points in the scleroscope reading. This apparently bears out the results of the investigations of the late Thos. D. West, who stated

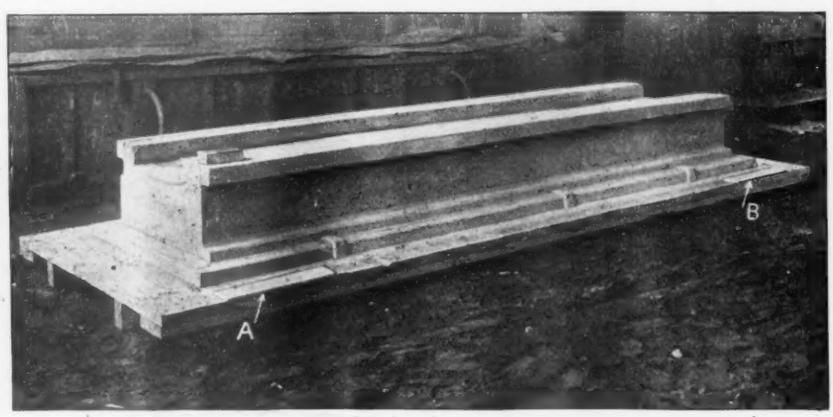


FIG. 9—TRAVERSE BED PATTERN ON BOARD WITH PADS *A* AND *B* WHICH GIVE RISE TO THE PATTERN

that the hotter the metal the greater the effect of a chill. The iron which solidifies at the gate being relatively very hot as compared with that which travels the full length of the casting over chills, is harder than the iron extending to the opposite end of the casting.

Personals

Charles Davis has been appointed foreman of the foundry operated by the Utah Copper Co., Garfield, Utah.

John F. Schuster has been appointed manager of the foundry operated by the Locomotive Finished Materials Co., Atchison, Kans.

P. J. Kroll has resigned as representative for the International Oxygen Co., New York, in the Pittsburgh and central western territory.

The Asbestos Protected Metal Co., Pittsburgh, has appointed O. K. Olsen of New Orleans, sales agent for Louisiana and the southern part of Mississippi.

Max E. Biefeld has been elected secretary and treasurer of the Otto Biefeld Co., manufacturer of boilers, structural iron, machinery and castings, Watertown, Wis., to fill the vacancy caused by the death of Richard Biefeld.

Fred Maple has resigned as foundry foreman of the Bettendorf Co., Bettendorf, Ia. The foundry employes presented him with a watch and a purse and tendered him a banquet at the Rock Island club, Rock Island, Ill., at which J. F. Webb acted as toastmaster. Mr. Maple has been affiliated with the Chicago Malleable Co., Chicago; the Parlin & Orendorf Co., Canton, Ill.; the Western Foundry Co., Chicago, and the Davenport Locomotive Works, Davenport, Ia.

Fred L. Wolf, who was chosen secretary and treasurer of the American Institute of Metals at the annual convention of the institute held at Boston, Sept. 24 to 27, has been associated with the Ohio Brass Co., Mansfield, O., for several years. Mr. Wolf entered the engineering department of that company in 1911 as a chemical engineer. He progressed rapidly and in 1917 was named engineer in charge of manufacturing, the position which he now holds. Mr. Wolf was born at Elmore, O., May 12, 1885. In 1892 he went to Toledo, O., when the family removed to that city. Upon his graduation from Toledo high school in 1904, he entered the University of Michigan, graduating from there in 1908 with the degree of bachelor of science in chemical engineering. From 1909 to 1910 he worked as a chemist in the plant of the Detroit White Lead Works, Detroit, resigning to accept a position as a chemical engineer at Cobalt, Ont. He terminated his duties at Cobalt in 1911 to join the engineering staff of the Ohio Brass Co. Mr. Wolf holds membership in the American Chemical society and the Alchemist society of the University of Michigan.

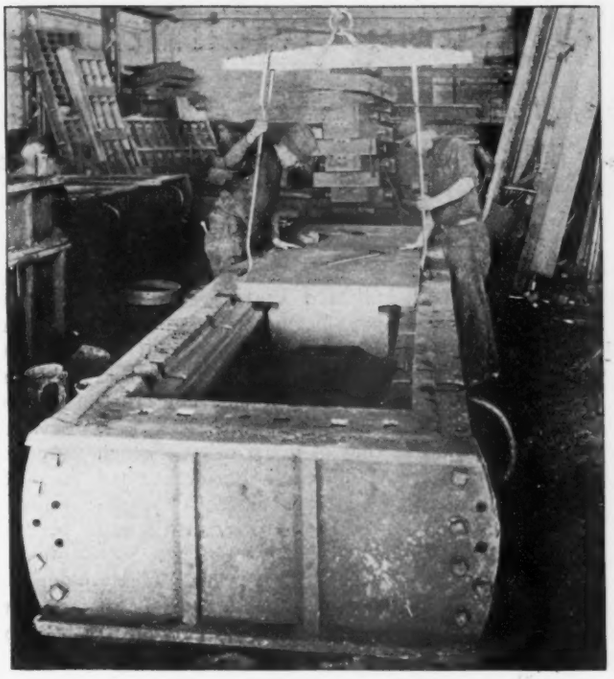


FIG. 10—CORING-UP THE TRAVERSE BED MOLD

A recently patented bearing alloy contains copper, 4 parts; antimony, 2 parts; nickel, 1 part, and lead, 1 part. This alloy, it is claimed, requires little lubrication.

Cadmium causes an explosion when added to molten copper and the addition should be made in very small pieces. Dense, brown fumes are given off from the copper up to the point of complete solidification.

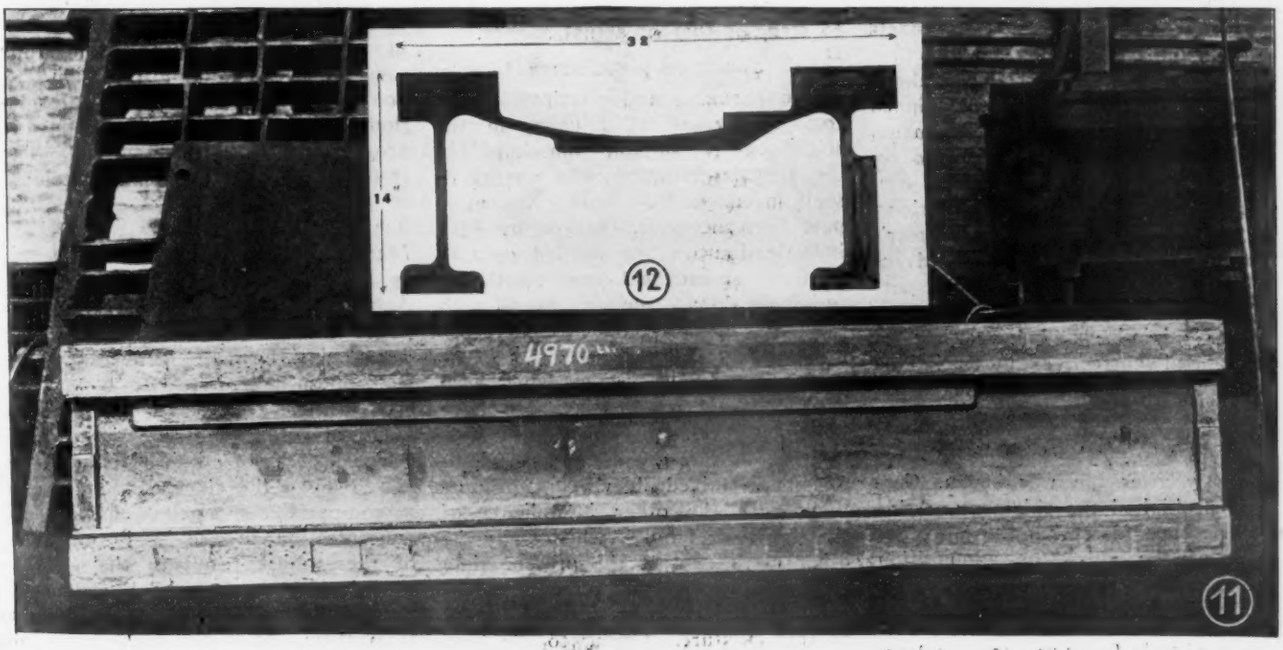


FIG. 11—THE TRAVERSE BED AFTER CLEANING, SHOWING THE MARKS OF THE CHILL. THE INSERT, FIG. 12, IS A CROSS-SECTION OF THE CASTING, SHOWING THE UNEQUAL DISTRIBUTION OF THE METAL

How the War Affects Manufacture of Crucibles

Imports of Plumbago and German Clay Cut Off Early in War —Experiments With Substitute Materials for Crucibles Proceed Slowly

By M McNaughton

LIKE many other industries, the manufacture of plumbago crucibles has been affected by conditions arising out of the war. The disturbances set up have extended to the users of crucibles, affecting them seriously in the way of increased costs and in some cases, reducing output because of a shortage of supply. It has been suggested that it would be well if the crucible user were more fully informed as to those details of crucible manufacture which have been most disturbed by war conditions, referring of course to the conditions of supply and demand of the essential materials of crucible making. The important and essential ingredients of the plumbago crucible are the plumbago, and the clay which serves to hold the crucible together in the process of manufacture and in use.

Before the war all of the clay for crucible purposes was imported and probably 95 per cent of the plumbago. The clay used almost exclusively came from the small town of Klingenberg in the western part of Germany. The mines are the property of the town and the profits from the operation of the mines largely meet the municipal expenditures. The clay is of remarkable quality and uniformity, and the extent of the deposit has made it an adequate supply against the large demands made upon it. These facts have made this clay by far the best yet known for the crucible maker's use. Clay was mined and shipped during the entire year, shipments reaching this side in from four to six weeks after leaving the mines. But, even with these favorable conditions, the maker usually carried a year's supply on hand to secure the advantage of natural drying, the clay carrying about 20 per cent free water, and to minimize and have time to detect and correct slight variations occurring from time to time in its quality.

Clay Shipments Stopped

Shortly after the war began, Germany prohibited the shipment of this clay, perhaps foreseeing the large demand of the allies for ammunition and metals from this country. The rapidly increasing demand for crucibles shortly after the beginning of the war indicated that a supply of clay usually sufficient to last a year would supply the needs of the manufacturers only a short time and that a substitute must be found. The crucible industry found itself in the same position as that of many others, which for years had relied on what had appeared to be an absolutely dependable supply, both as to quantity and quality.

So it happened that very quickly the manufacturer was launched on the sea of experiment at a time of rapidly increasing demand, which increased finally to such a point where users waived all claim for quality, provided quantity was sufficient.

Appreciating the difficulties ahead, the crucible maker warned his customers what might be expected by informing them that the quality of crucibles made from domestic clays was an unknown quantity and that crucibles would be sold only on that understanding.

As anyone familiar with their manufacture knows, the actual testing out of refractories is a very slow and long drawn-out process. In the case of china ware, the testing would be largely in the way of overcoming the difficulties of manufacture. In the case of crucibles these difficulties are not serious, but the real test it has to stand is that of actual service.

No Substitute for German Clay

The chemical and physical laboratory has been called upon, in the search for a suitable substitute for the German clay, but the results of such investigation have for the most part been negative, that is, by such investigation we are enabled only to eliminate from real test such materials as do not measure up to such standards as have come to be recognized.

Many score of clays have been examined and perhaps a score have given indications of possible successful use. A clay giving favorable indications is mixed in varying proportions with the other ingredients of the crucible, among which may be other clays (for at the present time a blended clay seems to be the solution) and trial lots are made, say six, of each mixture. Owing to the long time required to make and burn crucibles and adding to the time required for transportation and actual use, two months is the shortest period required to get results from such tests and it is more likely to be three.

If the result of such a trial is favorable, another lot is made up, this time of 50 or 100 pots and sent out to different users. If the results obtained by the different users are in practical agreement the information is of real value. But when the reports are not in agreement, as is often the case, the test must of course be repeated.

Test Results Unsatisfactory

In this connection it may be mentioned that one of the difficulties the crucible maker labors under is in getting informing reports as to the running of test lots of pots. This was particularly so during the period just passed. Many users did not appreciate the seriousness of the situation, and how important it was to the maker to get this information in a very accurate way. Later on as the rush of business increased, it of course became more and more difficult to keep accurate records, and undoubtedly the employment of many green workmen added to the uncertainty of the results obtained.

In order to obtain results as quickly as possible, many experiments have to be carried on simultaneously. Under such circumstances, a long time must elapse before information becomes available, but as the information accumulates there is steady progress toward the desired end. The results secured by the early attempts to use domestic clays were unsatisfactory. In certain cases the average heats secured were four or five as against 25 to 30 previous to the war. At the present time results are much better, from 15 up to 20 and 25 heats being the range of average service. These figures refer to an average size crucible, say No. 80, used in standard rolling mill practice.

The process of elimination has narrowed down the clays now in use to a comparatively small number, and concentration in the study and use of these must result in the steady, though perhaps slow, improvement in the quality of the crucibles made from them. It is not to be assumed that the testing of other clays is to

Presented at the Boston meeting of the American Institute of Metals.

FORMULAS FOR THE BRASS FOUNDRYMAN

Proprietary Bearing Alloys

The following bronzes are used extensively as bearing alloys, and while the names by which they were known when first produced have generally been discontinued, occasionally one of these alloys is specified by its original name. The list of alloys presented herewith permits of the easy identification of any of these alloys:

"S" Bearing Metal

	Per Cent
Copper	79.70
Tin	10.00
Lead	9.5
Phosphorus	0.80

"S" bearing metal also is used as an acid-resisting alloy. The amount of phosphorus can be varied to best meet the requirements of individual cases. The difficulties of making castings are increased in proportion to the increase of phosphorus. When the phosphorus is eliminated, the alloy becomes a straight 80 copper, 10 tin and 10 lead mixture.

Ex. B. Metal, Pennsylvania Railroad

	Per Cent
Copper	76.80
Tin	8.00
Lead	15.00
Phosphorus	0.20

"Ex. B. Metal" is used for car journal bearings and also sometimes for anti-acid purposes.

Ajax Plastic Bronze

	Per Cent
Copper	65
Tin	5
Lead	30

Ajax plastic bronze also is used extensively for car journal bearings and occasionally is used as an acid-resisting alloy.

FORMULAS FOR THE BRASS FOUNDRYMAN

Proprietary Bearing Alloys

Ajax Metal

	Per Cent
Copper	77.00
Tin	11.50
Lead	11.50

A small amount of phosphorus may be added to Ajax metal to reduce oxides formed in melting. About 0.25 per cent of 15 per cent phosphor copper is sufficient for this purpose.

Carmelia Metal

	Per Cent
Copper	70.00
Tin	4.50
Lead	15.00
Zinc	10.00
Iron	0.50

Carmelia metal is a complex alloy. The advantages of the iron addition are rather doubtful.

Carbon Bronze

	Per Cent
Copper	75.00
Tin	10.00
Lead	14.50
Carbon	trace

Cornish Bronze

	Per Cent
Copper	77.80
Tin	9.50
Lead	12.50
Phosphorus	0.20

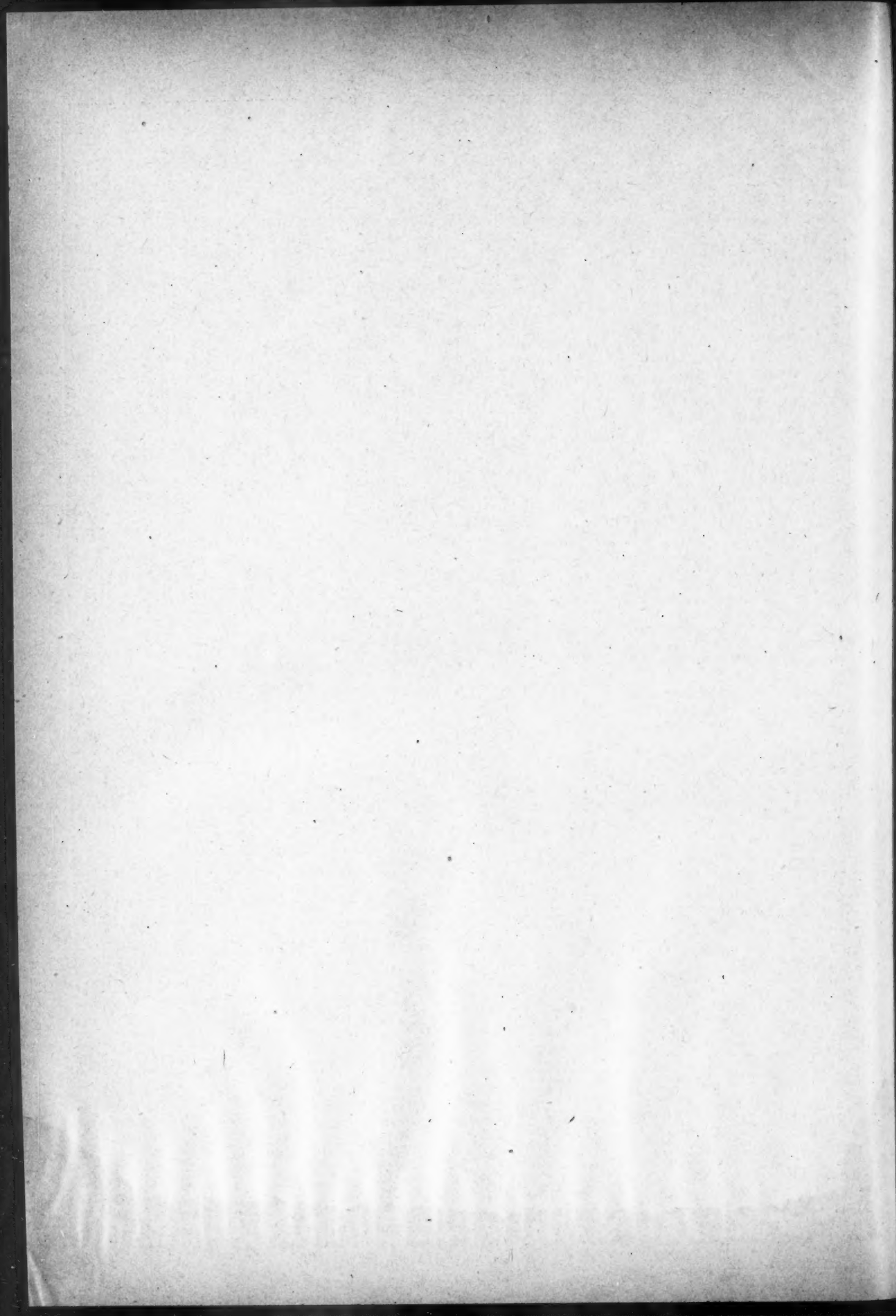
Damascus Bronze

	Per Cent
Copper	76.90
Tin	10.50
Lead	12.50
Phosphorus	0.10

THE FOUNDRY DATA SHEET, NOVEMBER, 1917

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note-book form.



be stopped. This work will go on until the best clay or clays for the purpose has been discovered.

As some users know, there have been lapses in the forward progress of the quality of the crucibles during this period of change. Such variations are in part explained by the fact that the clay miners in the earlier period were not prepared to meet the demands made upon them, and in later periods to the fact that railway transportation fell down for weeks at a time, during which periods shipments could only be made by express and of course at enormous expense. Furthermore, these clay mining operations are mostly open workings, and subject to weather conditions and unproductive on this account for days and weeks at a time. The clay operators having prospered have so increased their equipment that a sufficient production is now reasonably assured, and with the government in a position to control shipments, transportation troubles should not recur.

The supply of plumbago for crucible making comes mostly from the Island of Ceylon, not more than 10 per cent coming from Madagascar and America. The Ceylon plumbago differs from the other kinds by being more cubical in its crystalline structure, while the Madagascar and American graphite is in the form of thin flat flakes. The stock of Ceylon plumbago usually carried is a two to four months' supply, with a similar amount contracted for. Shipments come usually by direct steamer and require from five to eight weeks. The supply is usually regular, but may be interrupted by reason of extremely wet seasons, quarantine restrictions and perils of the sea. At the war's commencement, stocks in the makers' hands were probably larger than usual on account of bad business conditions prevailing in this country at that time.

For the information of those who have thought that the use of domestic clay should have a lowering effect on the cost of crucibles, it is sufficient to say that its cost is now more than double that of the German clay previous to the war.

In October, 1914, the British government placed an embargo on plumbago exports from Ceylon, which lasted more than four months. As a result of this interruption stocks here were entirely cleaned out.

In the meantime the demand for crucibles was growing and the insistent demand for shipments of plumbago on old orders, as well as the increase in quantity on new orders, started an upward movement in prices which never stopped until they were more than three times what they were before the war began.

After the embargo was raised shipments came forward with sufficient regularity to generally meet the requirements, although all of the makers would at times be out of material for short periods.

Raw Material Supply Improves

The conditions as to the supply of both of these materials, clay and plumbago, are much more satisfactory than they were a year ago. Supplies are calculated on a much larger output of crucibles, nearly all of the makers having increased their production. The annoying shortage which prevailed during 1916 will not occur again as a result of insufficient works capacity. Crucibles are of much better quality on an average than during that period so that the same number of crucibles will melt a much greater quantity of metal. The quality of the crucibles will be improved still further as more and more knowledge of the domestic clay is acquired.

The crucible maker expects to be able to meet any emergency that may come, and to do it in a way far more satisfactory to the crucible user than has been the case during the past two years.

Suggestions For Melting Brass

IN AN address at a meeting of the London branch of the British Foundrymen's Association recently, H. G. Barrett stated that the demands of engineers in the past for bronze and brass castings in most instances have been prompted more by a name than by a knowledge of the properties of the alloys required. There is no reason, Mr. Barrett contended, why this practice should prevail at present, as nonferrous alloys to fullfil special requirements have been made available by extensive research and there is now at the disposal of foundrymen, information as to the physical properties of alloys in a convenient form for immediate use.

Metals and alloys of guaranteed analysis can be purchased and many foundrymen are now using ingot metals instead of alloying the metals in their own foundries. In the selection of copper ingots, it should be noted that underpoled ingots are distinguished by a longitudinal furrow on the upper surface; overpoled ingots by a longitudinal ridge, while good, tough, copper ingots should have neither ridge or furrow, and except for a slight depression of the surface, due to contraction, the upper surface should be comparatively smooth. Underpoled copper and overpoled copper have a blue tint on the surface of the ingot on each side of the ridge or furrow, and good copper has a red, silky appearance in fracture.

How to Test Tin

The purity of tin can be ascertained by a rough test. If the tin is melted, and then when near the freezing point, it is poured into a small ingot, and the surface remains bright, the tin is pure, but if it assumes a dull, frosted appearance, it contains impurities. This appearance becomes very marked when lead is present. The crackling sound heard when tin is bent is also a rough indication of its purity.

Scrap is one of the most perplexing materials the brass founder has to contend with, and in spite of the economic advantage obtained by its use, it requires much judgment in sorting, and in proportioning additions of zinc, tin and lead to obtain successful results.

The composition and character of an alloy cannot always be determined by its color. It is possible to make a high zinc brass that will resemble gun metal when machined. Aluminum bronze also is difficult to identify, and there are many other metals that also add complications to the use of scrap when run down in crucibles. The safest way to use scrap to obtain uniform castings is to melt it in an air furnace, run it into ingots, obtain an analysis and so learn the deficiency of tin and spelter. When the ingots are remelted for use the necessary additions of white metals can be made to bring the alloy to the composition desired.

A convenient size of air furnace is one holding around 3000 pounds of metal. The main points in operating such a furnace are uniformity in firing so as to raise the temperature quickly, and keep it constant, and to create a reducing atmosphere that will protect the metal from oxidation. In starting the furnace, only a few hundred pounds of metal should be charged at first, so as to form a bath in the well of the furnace. This bath is quickly brought to a temperature that will enable it to dissolve additional metal. After an addition, the bath should be allowed to regain its

heat, to dissolve more solid metal, and this process is continued until all the metal comprising the heat is melted.

When firing the furnace, the damper should at first be lowered to prevent cool air from passing through the furnace. The coal or coke should be spread evenly over the whole surface of the fire and not banked in spots, as this causes variations in temperature. The addition of too much fuel at a time chills the furnace. This is indicated by the production of a large amount of smoke. The clinkers can be easily removed by inserting a flat bar between the fire bars from underneath, providing a fulcrum for the bar to rest upon, so it will form a lever when the end extending from the furnace is depressed. This action forces the other end up between the bars and dislodges the clinkers, which are then removed through the furnace door by the aid of a rake. This should be done immediately before firing. The damper should also be lowered before the furnace is charged, and the surface of the metal must be kept covered with charcoal.

Pieces of hard wood and old bags filled with sawdust can be thrown onto the metal and will assist in economizing charcoal. When the metal is ready to be tapped from the furnace, a little phosphor-copper should be added to assist in reducing the oxides.

Removing Defects in Metal

The melting operation may produce many defects in the metal due to the inclusion of oxides or dross, and it is not easy to remove them once they get into the alloy. Remelting will remove gas holes produced by defects in molding, but will not remove those produced by oxidation. For this latter defect, deoxidizers must be used, but they are not all successful, as in removing the oxides, gases which increase the porosity may be generated.

A satisfactory method of cleaning the metal is to place a little plaster of paris in the bottom of the crucible before charging. After the metal is poured into the crucible, stir to dislodge the plaster, causing it to rise through the metal and carry the entangled oxides with it.

The iron taken up by the metal from the stirring rod does no harm, as iron-bronze consisting of 5 per cent iron, 10 per cent tin and 85 per cent copper, was used in Europe as far back as 1850. Some metal has also been discovered that contained as much as 10 per cent iron, as well as 10 per cent tin. It was used for making field guns.

Salt is a valuable flux, but objectionable on account of its irritating fumes. Its value is due to its readily combining with sulphur, thus forming a continual protection to the metal during the melting period. Chloride of lead is useful when the scrap is very dirty, and should be used in conjunction with plaster of paris as described. When the crucible is taken from the furnace and has been stirred, the chloride of lead should be added by enclosing it in a piece of paper tied to the end of a rod, which should be plunged quickly to the bottom of the crucible.

PROBLEMS OF THE BRASS FOUNDER

What To Do and How To Do It

Aluminum Casting Difficulties

We are experiencing difficulty in the manufacture of small aluminum castings due to the fact that the metal will not lie on the sand in the bottom of the mold unless the sand is warmed. Can you recommend a better method of casting aluminum? The mixture consists of all scrap aluminum. What is the best sand to use for these castings?

The aluminum will lie on the bottom of the mold provided the latter is rammed soft and the metal is poured cool. The thickness of the casting should determine the temperature at which the metal is to be poured since a thin section will probably have to be poured with the metal at red heat. However, if this temperature can be avoided without causing misruns, better castings will be obtained. The sand at the bottom of the mold should be rammed soft, but not soft enough to produce swells and the molds should be vented with fine wire over the spots where the metal fails to lie quiet.

You will always experience the danger of a high zinc content when using scrap aluminum and this also may cause the difficulty outlined. The remedy is to use new aluminum with the scrap and to reduce the zinc content to a point where it is less difficult to obtain good castings. Therefore, some study will be necessary to determine exactly where the difficulty lies, and after the cause has been ascertained, the remedies suggested may be applied.

Segregation of Lead

We have an order for a number of castings to be made from the following mixture: Copper, 66 per cent; tin, 6 per cent; lead, 27 per cent, and phosphor-tin, 1 per cent. The metals in this alloy do not mix thoroughly, however, and any suggestions that you can make that will help us to overcome this difficulty will be appreciated.

No trouble should be experienced in making this alloy, since a mixture containing 30 per cent lead, 5 per cent tin and 65 per cent copper is in daily use and ingots of this composition may be purchased from the manufacturers of metal ingots. We suggest that the prosphor-tin be omitted, as this undoubtedly has a tendency to throw the lead out of solution. Adding 1 per cent nickel is advisable.

Melting Brass in the Cupola

We expect to make a large brass casting, 54 inches in diameter, 17 inches in depth, 1¾ inches thick and weighing 1700 pounds. The metal must be close-grained since the casting is to be cut into rings, ¼ inch thick. What mixture do you recommended and how should we proceed to melt the brass in a 32-inch cupola?

A comparatively coarse sand with a large proportion of new sand should be used for making the mold and the casting should be gated at the bottom, using dry sand runner cores if a three-part flask is not employed. Two runners should be provided, located opposite each other across the circumference of the ring and four 3-inch risers should be placed on the cope equally distributed around the circumference. These should be gated to the outside of the ring with heavy gates to provide a sufficient amount of the metal to enable the risers to feed the ring.

Heavy red brass scrap is suitable for cupola melting and after the metal has been charged on the coke, add a small amount of salt before making a further charge of coke. The

metal should be melted very hot and a layer of burning charcoal should be placed in the bottom of the ladle onto which the metal is tapped. If red brass scrap is not available, use the following mixtures: Copper, 85 per cent; tin, 5 per cent; lead, 5 per cent, and zinc, 5 per cent. If possible, run this mixture into ingots and re-melt them in the cupola. The ingot metal should be melted in a brass furnace.

Metal From Brass Concentrates

We have a large quantity of brass concentrates which we desire to remelt into ingots. The concentrates are finely divided and contain copper, 83 per cent; tin, 2 per cent; zinc, 5 per cent, and lead, 10 per cent. How would you suggest treating this product to recover the maximum amount of zinc and copper?

If the concentrates carry considerable dirt, such as carbonaceous, silicious or iron matter, they should be melted in a water-jacketed cupola and plenty of limestone should be added to produce a slag having the consistency of cream. Less than 1 per cent of the copper should be carried into the slag, but it is probable that 50 per cent of the zinc will be lost. If the fineness of the concentrates causes trouble, they should be briquetted, which can be accomplished by mixing them with plaster of paris, or stucco and forming the mass into bricks. The plaster of paris will serve as a flux, emitting part of its oxygen and part of its sulphur. The iron present will combine with the oxygen to form ferrous oxide and the copper will absorb the sulphur. The ferrous oxide will combine with the sulphur and go to the slag, and the copper sulphide will react with any oxide and form metallic copper and sulphur dioxide. Therefore, the plaster of paris will do no harm. If the concentrates are melted in an open-flame furnace with fuel oil, it would be advisable to add new metals to change the composition of the ingots to some standard alloy containing less lead to prevent hard spots appearing in the castings made therefrom.

Aluminum Mixture For Pistons

We would like to obtain an aluminum mixture suitable for automobile pistons.

Mixtures of aluminum alloys suitable for the purpose mentioned were published on Data Sheet No. 235 in the June, 1917, issue of THE FOUNDRY. This formula is for a strong aluminum alloy and directions are included for making it. If this mixture is too difficult to produce, or is unsuitable for other reasons, other alloys will be found on Data Sheets Nos. 241 and 242 in the September issue of THE FOUNDRY.

Bronze to Resist Mine Water

We would like to have a bronze mixture that will satisfactorily resist the corrosive action of mine water containing a high percentage of sulphuric acid and sulphate of iron.

The resistance of a bronze casting to the acid of mine water is in proportion to its freedom from oxides rather than being attributed to its composition; from this it may be inferred that the composition of a bronze is secondary to its quality when required to resist the corrosive action of mine water. An alloy consisting of copper, 90 per cent and tin, 10 per cent, which may be cast easily, will resist the action of mine water as well as anything that may be employed. However, the castings must be sound, dense and free from oxides of copper and tin. If a strong metal is desired, we recommend the use of this alloy, but we desire to emphasize the necessity of protecting the copper, while melting, with some fusible flux, such as glass, in addition to the charcoal generally employed.

A cheaper alloy than the one given follows: Copper, 86 per cent; tin, 8 per cent; zinc, 5 per cent, and lead, 1 per cent.

In some instances the high-leaded alloys can be used to advantage.

The following mixture may be employed where the strength desired of the casting will permit its use: Copper, 78 per cent; tin, 7 per cent, and lead, 15 per cent. However, any of the alloys given will be satisfactory.

What is Aluminum Nitride?

We were very much interested in the article on the conservation of metals published on page 209 of the June issue of THE FOUNDRY, *especially the mention of aluminum nitride, but as we cannot find any reference to this substance we assume that it should have been nitrate or nitrite instead of nitride. Also, would a furnace that is arranged so that the hot air is kept away from the metals in melting, be serviceable in melting aluminum or brass, and would some of its value be due to the melting without the use of fluxes which may possibly be injurious to the metal?*

The word nitride in this article is used correctly. A nitrate is a salt of nitric acid, such as sodium nitrite ($NaNO_3$). A nitrite is a salt of nitrous acid, such as sodium nitrite ($NaNO_2$). Aluminum nitride is formed in electric furnaces from aluminum oxide by the Serpek process, according to the following reaction: $Al_2O_3 + 3C + N_2 = 2AlN + 3CO$. The reaction is strongly endothermic, absorbing, according to Richards, 213,220 calories.

Aluminum nitrate is formed by dissolving aluminum in nitric acid, or by dissolving the hydroxide in the same acid. Its formula is $AL(NO_3)_3 9H_2O$. The formula of aluminum nitride is ALN. The two substances are entirely different.

A furnace which does not bring in contact the products of combustion in melting is desirable. Fluxes, however, rarely harm the molten metals as they are generally too stable chemically to be broken up by the metals melted in ordinary practice.

Anti-Acid Bronzes

We would like to have several anti-acid bronze mixtures. We desire to make these alloys from new metals and they should have a tensile strength ranging from 40,000 to 60,000 pounds per square inch.

An excellent alloy for anti-acid purposes consists of copper, 90 per cent and tin, 10 per cent. When carefully made, test bars cast in sand should develop a tensile strength of 40,000 pounds per square inch. The term *carefully made* implies exercising every possible precaution to prevent the oxidation of the metal during melting. If a tensile strength of 60,000 pounds is required, either manganese or aluminum bronze must be employed. To make manganese bronze it is customary first to mix a hardener as follows: Wrought iron, 18 pounds; 80 per cent ferromanganese, 4 pounds, and tin, 10 pounds. Melt the iron and manganese together, and when liquid, add the molten tin, stirring meanwhile. Pour the cast into water for the purpose of granulating it. For mixing the bronze use copper, 56 pounds; aluminum, 0.5 pound; zinc, 41.5 pounds and add 2 pounds of the hardener.

To produce aluminum bronze, melt 90 pounds of copper under charcoal and when liquid, add 10 pounds of pure aluminum; stir and cast into ingots.

Making Vanadium Bronze

We have received a government order for vanadium bronze castings weighing from 60 to 100 pounds. Kindly let us know how to make this mixture.

Vanadium bronze is a manganese bronze that has been treated with vanadium. The mixture is approximately as follows: Copper, 57 per cent; tin, 1 per cent; 1 per cent of 30 per cent manganese-copper; iron, 1.5 per cent; aluminum, 0.25 per cent; zinc, 39.25 per cent with a sufficient amount of vanadium to deoxidize the mixture. Any manganese bronze alloy that will meet the specifications as to chemical composition and physical properties can be used for this work and unless experienced in making manganese bronze, it is advisable to purchase the ingot metal from some of the manufacturers of this mixture.

The Role of Metallography in the Foundry

How the Microscope Can Be Used to Test and Control Product —Industry Now Awakening to Importance of Metallography

By Robert J Anderson

THE object of this contribution is to call attention to the possibilities for important advances in the application of the metallographic microscope as a means of testing and controlling the products of our foundries. As is usually the case with all important developments, skepticism has prevailed, and mistakes have been made; it even may not be overdrawing the history of metallography to remark that the most absurd predictions have been advanced as to what the microscope could accomplish. All this has done much to confound the metal industries. Many difficulties have had to be overcome, but as knowledge has progressed, and the number of applications have increased, the causes of trouble have gradually been eliminated. To set forth a complete treatise on the scope of metallography and its application to the iron and steel foundry business would be a task of considerable magnitude, mainly because of the large mass of material which has been published in the metallographic field, and secondarily because of the inherent difficulty of a logical presentation of the subject. Rapid strides have been witnessed in the past few years, so that at the present writing the methods of metallography find extensive application as a means of control in the metal industries and even in foreign fields. The knowledge we now have relative to the relation which grain size bears to the physical properties of metals and their alloys has given rise to a new method of scientific regulation.

Metallography's Rapid Advance

Thirty years ago, metallography as a science was virtually unknown, and it is only within the last 15 to 20 years that it has received serious consideration by manufacturers and consumers as a valuable means of metal testing. The development in the early years of its history was slow, but the advances in the past five years have probably exceeded all those previously made. At present metallography is taught in almost all technical and engineering institutions of university grade, and the methods of metallographic testing find wide use in iron and steel and in nonferrous metallurgy.

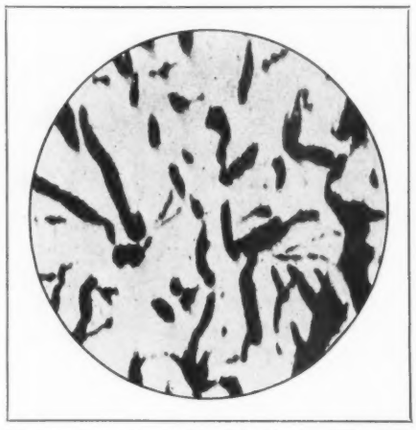


FIG. 1—GRAY CAST IRON, UNETCHED
(Magnified 100 Diameters)

Metals and alloys owe much of their industrial importance to their physical properties, and it is in the testing and determination of these physical properties that the methods of metallography have come to be indispensable. The physical properties of metallic alloys are dependent upon their structural compositions rather than upon their ultimate chemical compositions, and in revealing the former, metallography demonstrates its value. The chemical analysis furnishes information which is highly desirable, but it cannot make possible much knowledge concerning the structure and physical constitution of substances. It will be recalled by most people interested in iron and steel, that the chemical laboratory experienced difficulty in the early days in finding a place in the works; metallography has gone through the same trying stage in its short existence. That it has demonstrated its true worth is proved beyond doubt by the large number of manufacturing concerns that have installed laboratories and by the service it has rendered.

FIG. 2—WHITE CAST IRON, UNETCHED
(Magnified 100 Diameters)

Why Foundries Have Been Slow

It appears that the foundry interests have not taken to metallography with the interest which the science deserves, and there is unquestionably sufficient reason for this condition. In the first place, the foundry interests are, broadly speaking, considerably diversified, and their tonnage per unit is smaller than in the case of steel works, so that the installation of a laboratory and the employment of a metallurgist would not appear warranted from the standpoint of first cost. Secondly, it seems that in comparison to certain other industries fewer men highly trained in science have entered the foundry field. The reason for the latter condition is not exactly apparent because the opportunities are large. Only a small percentage of the foundries in this country employ metallographic methods, so that the field would appear to be practically virgin. Therefore, by deduction from what metallography has accomplished in other fields, the writer has every reason to believe that a consistent and intelligent application of this science will improve the product of the foundries in a measure out of all proportion to the amount of endeavor.

There is no attempt in this paper to explain the methods of metallography. As regards foundry applications, the subject has been dealt with at length by others. Several text books on the subject have appeared in the past few years, and we now have "Metallography", by Cecil H. Desch; "The Metallography and Heat Treatment of Iron and Steel", by Albert Sauveur, in which the practical aspect is well cared for; "The Metallography of Steel and Cast Iron", by H. M. Howe; "Metallic Alloys", by G. H. Gulliver; "Physical Metallurgy",

Read at the 1917 annual convention of the American Foundrymen's association. The author is metallurgist, the Cleveland Metal Products Co., Cleveland.

by Walter Rosenhain, a lucid exposition; and "Metallographie", by W. M. Guertler. The *Journal* of the Iron and Steel Institute, London, devotes considerable space to the ferrous field; and the *Internationale Zeitchrift fur Metallographie* covers both ferrous and nonferrous metallography. Wm. Campbell recently summarized the late progress in metallography.

Metallography of Cast Iron

The available literature on the metallography of cast iron is indeed meager, so that it may not be out of place here to recall a small portion of the present knowledge. The paucity of literature is one criterion from which we may deduce that no great deal of scientific work has been accomplished, at least not in any measure comparable with what has been performed upon both carbon and alloy steels. It appears to be an idle ceremony to discuss in this place the phenomena which occur when alloys of varying carbon content pass from the liquid condition to room temperature. These phenomena are readily secured from a consideration of the now well-known carbon-iron diagram. It suffices to state that our knowledge of the transformations in steels and cast irons is based upon this diagram, as are all methods for heat treatment.

For a proper understanding of the structure of cast irons, or other metallic alloys, it is of prime importance to observe the macrostructure or structure as it appears to the naked eye. This is equivalent in practice to the examination of fractures of broken castings. Sudden breakages are indicated, in general, by a granular appearance, while fractures which have resulted from repeated stresses will be smoother. Macroscopic examination may show, in a failed part, at what point the fracture initiated, due to local defects. In the event that local defects are not found or in case microscopic examination is desirable, micro-sections should be secured. Macroscopic examination may readily distinguish between various types of irons by simple inspection of the fracture, but it is not to be relied upon as absolute.

Knowing the constitution and heat treatment of any given iron, we can predict with certainty what its structure will be. In general, the latter will be dependent upon the percentage of carbon present, upon the condition of the carbon, and therefore upon its chemical composition or heat treatment, or both. The carbon present in cast iron may be in three different forms: First, entirely in the combined forms, as cementite; second,

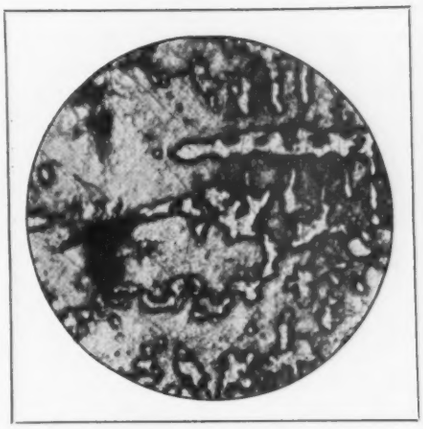


FIG. 3—STRUCTURE RESULTING FROM ANNEALING AT TOO LOW A TEMPERATURE
(Magnified 100 Diameters)

entirely in the uncombined form, as graphite; and third, partly combined and partly uncombined. These three occurrences are considered in the following paragraphs, but first it may be well to consider the formation of combined and graphitic carbon. When cast iron freezes, the carbon remains in the combined form as Fe_3C, but this is an unstable compound, so that the reaction

$$Fe_3C = 3Fe + C$$

is always striving to occur. Two factors are particularly cogent ones in promoting the formation of graphite: First, slow cooling during and below the freezing range; and second, the presence of silicon. The conditions most favorable to the production of combined carbon are: First, rapid cooling during and below the freezing range; and second, high manganese or sulphur content.

Iron and Its Carbon Content

Irons totally free from combined carbon are rare, the usual so-called gray irons having at least some part of their carbon in the combined form

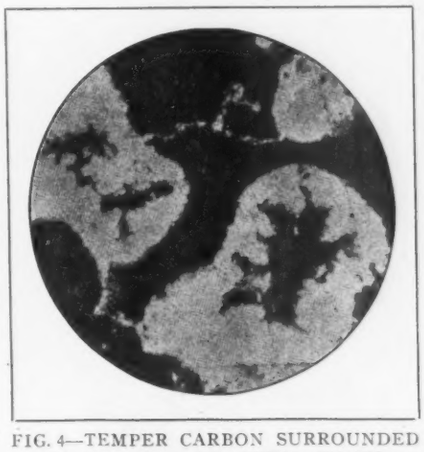


FIG. 4—TEMPER CARBON SURROUNDED BY FERRITE IN TURN ENVELOPED BY PEARLITE
(Magnified 100 Diameters)

as Fe_3C. However, to consider an iron whose entire carbon content is in the graphitic condition, we deduce at once that only two metallographic constituents can be present, graphite and ferrite. A commercial gray iron as observed under the microscope is shown in Fig. 1. The graphite appears as long curved plates embedded in the soft ferrite matrix. These plates so effectively destroy the continuity of the ferrite that the ductility of the iron is removed. Where graphite occurs in small rounded particles as in malleable cast iron, the matrix exhibits the normal ductility and malleability of ferrite. Commercial irons as alread stated, normally contain some combined carbon, those with less than 3 per cent nearly always having some combined carbon.

Structure of Cast Iron

White cast iron is cast iron containing carbon only in its combined form and consequently free from graphite. Macroscopically, its fracture is white and metallic in appearance. The conditions already enumerated as being favorable to the production of gray iron must be absent, so that white irons are dependent for their occurrence upon either one or a combination of the following: First, rapid cooling during and below the freezing range; and second, high sulphur or manganese content. Indeed an iron may be white even with high silicon and low manganese and sulphur in case the freezing is sufficiently rapid, or it may be white even with slow freezing if the sulphur and manganese are sufficiently high and the silicon low enough. Microscopically, a slowly cooled white iron will consist of pearlite and cementite. Such an iron is illustrated in Fig. 2; the white areas are cementite, while the dark ones are pearlite not resolved at the magnification employed. White cast iron is nonmalleable and very hard and brittle. These qualities are due to the large amount of free cementite present, this constituent itself being hard and brittle.

In the majority of commercial irons as already stated the castings usually contain both combined carbon and graphite, usually from 0.25 to 1.50 per cent combined carbon and the remainder graphite. Where irons are partly gray and partly white in appearance, they are called mottled irons.

The subject of malleable iron has been dealt with by Dr. Moldenke, and by Leasman and Storey, and others. Malleable iron has not received its full quota of scientific attention, if

published data can be any criterion. A great deal more is no doubt known, to a few, concerning the process of malleablizing than the altogether sparse literature would indicate, because of the secrecy which is supposed to and actually does overhang the process. Malleable castings are cast initially as hard white cast iron and are rendered somewhat malleable by, in part, graphitizing the cementite and converting the carbon into small rounded particles, and in part by burning out some of the carbon by the oxygen of the packing materials. In view of what has gone before it appears useless to dwell on the subject at greater length unless it be to point out how the metallographic microscope has served as an efficient tool in some of the researches made in this process. Photomicrographs by Storey show the influence of packing materials, temperature of annealing, and time of annealing in the malleablizing process. In Fig. 2 is seen a normal white iron where the carbon is all present in the combined state; the white areas represent cementite while the dark areas are pearlite.

The data obtained from Storey's researches show that when malleable is annealed for too short a time or at too low a temperature and slowly cooled, the structure consists under the microscope of ferrite and cementite and temper carbon, as shown in Fig. 3. Too rapid cooling after correct annealing results in a structure of temper carbon enclosed by ferrite, the latter being in turn enclosed by pearlite, as in Fig. 4. Proper annealing results in the structure shown in Fig. 5, consisting of ferrite and temper carbon.

Methods and Apparatus

In selecting microsections for examination under the microscope, it is usually not important to select the position in a casting from which the piece is taken, unless it is to observe local conditions. In the case of failure of metal in service, it is necessary that the sections should be taken from a position close to the fracture, as in many instances the casting may be sound with the exception of the part which failed locally. Stead remarked on this matter in the following manner:

"The importance of this is not always recognized, and specimens taken from positions far removed from the seat of failure are occasionally sent to the expert for examination and report as to the cause of failure—a proceeding which is equivalent to asking a medical practitioner to examine one's perfectly sound toe with the expectation that he will be able to tell why there is a tumor on his neck."

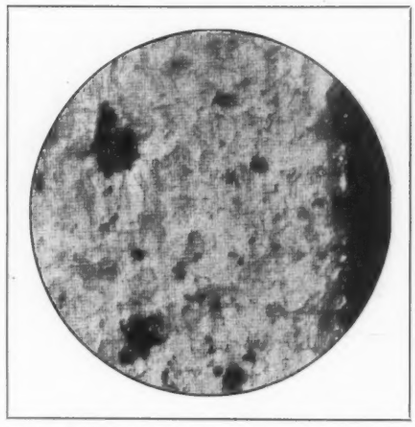


FIG. 5—MALLEABLE CASTING SHOWING CARBONLESS RIM
(Magnified 100 Diameters)

The use of motor-driven apparatus for grinding and polishing operations is to be recommended in preference to hand work, as the latter is tedious. Where a large number of microsections are to be prepared, as in routine work, power polishing is eminently more suitable.

For the detection of slag inclusions, porosity, oxides, sulphides, etc., the sections may be examined unetched. For the determination of the constituents and for distinguishing between occluded substances, it is necessary to etch. The sections are treated with reagents which have been found to be most suitable, or they may be heat tinted until the constituents assume differential oxidation films. The reagents in common use have been described in the literature of metallography, as has been the heat-treating method of Stead.

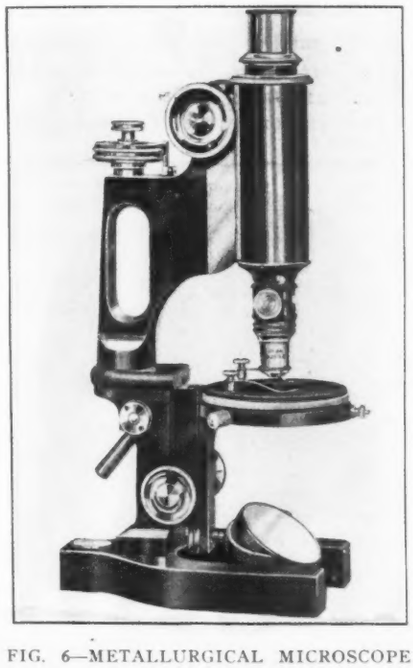


FIG. 6—METALLURGICAL MICROSCOPE

Any compound microscope fitted with an illuminator for opaque objects will serve for examinations, but it will be found best to obtain a metallographic microscope such as is supplied by various makers. A satisfactory instrument is shown in Fig. 6. The methods of examining and the apparatus required for photography have been described at length elsewhere and need not be dealt with in this paper.

Impurities in Iron

As is well known, the common impurities in cast iron, as in steels, are the elements sulphur, manganese, silicon and phosphorus. Since all cast iron which is not refined in steel-making processes is used for making iron castings, the impurities present in the pig iron will be present in the iron castings, and the fundamental characteristics of those castings are direct functions of the percentages of the different impurities present. Carbon, either combined or graphitic, or both, is of course a constituent of all iron castings. The impurities mentioned exert a dual influence; first, upon the iron itself; and second, upon the carbon.

Sulphur in increasing percentages increases the amount of combined carbon present in any given iron, and when present as FeS the effect is even greater than when in the form of MnS. Having observed the fracture of an iron, the methods of metallography are valuable in supplementing the macroscopic observation. To employ these methods for the approximate determination of sulphur in cast iron, the following procedure is adopted: A piece of iron is polished and pressed firmly upon a piece of photographic silver bromide paper, which has been immersed in dilute sulphuric acid; the contact of the iron and the paper is maintained for a given length of time, and the amount of brown stain of silver sulphide formed is an indication of the percentage of sulphur present. This method has found considerable application in many steel works to determine segregation of sulphur in steel. The method has not found any wide use in the foundry, but there is no reason why it should not be useful there also.

The effect of manganese is to increase the combined carbon in an iron, but its influence is not as potent as that of sulphur. Also, it should be stated that since considerable of the manganese is in the form of MnS, it does not exert the effect of manganese in the elemental condition. Manganese

robs FeS of its sulphur, so that the ultimate effect of manganese is to decrease the percentage of combined carbon present in the iron. Any manganese in excess of the amount required to form MnS is in the form of the manganiferous cementite, $(FeMn)_3C$, and consequently increases the amount of combined carbon. This effect of manganese is therefore apparently contradictory.

Effect of Phosphorus

Phosphorus element also exerts an apparently contradictory effect upon irons in that it tends to increase the percentage of combined carbon, but it also has the effect of lengthening the period of time of the mushy stage, i. e., the range between the liquidus and solidus. This increased period of time promotes the graphitization of cementite. Micrographically, the occurrence of the reaction, $Fe_3C = 3Fe + C$, can be recognized by the contiguity of the graphite and ferrite which are products of the reaction. Graphitization is promoted by the presence of silicon and occurs with greater rapidity at high rather than low temperatures. The phosphorus, by increasing the length of the mushy stage, consequently favors graphitization, and the combined carbon will therefore be lower. With low silicon and high phosphorus, the tendency for combined carbon to increase is strong; when silicon is high, the tendency is towards graphitization; when the phosphorus is high, chemically it has the effect of retaining carbon in the combined stage, regardless of the length of the mushy range. Phosphorus may then tend to keep the carbon in the combined form if other chemical influences, as silicon, are not potent; it may hasten the precipitation of graphite if the physical conditions are such that the graphite is bound to precipitate.

A word on the mushy stage may not be out of place: It exists, as already indicated, in the range of temperature between the liquidus and solidus. During this period, the cooling metal consists of a mechanical mixture of molten mother metal and solid particles of primary austenite. All cast irons pass through this stage with the exception of that iron having eutectic composition. The lower limit of the mushy range is constant for cast irons, free from impurities, at 1135 degrees Cent., the freezing temperature of the eutectic; the upper limit of the range varies with the carbon content on either side of the eutectic composition. Impurities may change the lower limit of the range.

In gray iron, that is one where extensive graphitization has gone on, almost all the phosphorus is present as phosphide of iron, Fe_3P, segregated in isolated masses throughout the iron. The phosphide of iron is readily recognized microscopically; it is not affected by dilute acids, but the metallic portions between the phosphide and the graphite are readily attacked. If then a polished micro-section be etched with dilute HNO_3, the phosphide will be seen bright under the microscope. Where the phosphorus is high, these bright spots of phosphide can be seen macroscopically, but when the phosphorus is low the microscope is required for their detection. Metallographic methods readily offer a procedure for determining whether an iron is high or low in phosphorus. However, microscopic analysis must be regarded as only approximate and cannot entirely supplant chemical analysis.

Silicon promotes the precipitation of carbon in the form of graphite; an iron containing say 3 per cent silicon will have practically no cementite, if the cooling is slow and the sulphur and manganese low. With 3 per cent silicon, the formation of austenite during solidification may be partially prevented, and graphite instead of cementite may be precipitated at 690 degrees Cent. Silicon is therefore an important element in control of foundry products because of its effect upon the condition of the carbon. Silicon probably forms with iron the silicide, FeSi, which is soluble in ferrite. There is no metallographic method of distinguishing silicon unless through a rough approximation arrived at from the graphite present. It is stated, however, that under similar conditions the greater percentage of silicon present in ferrite, the slower the etching of that constituent.

Conclusion

As has already been stated, it appears to be most singular that metallography has not yet rendered the quota of results to the foundry business which it is capable of, considered in the light of its immense value to steel manufacture. Originally, when the microscope was introduced as an aid in the control of steel products, it was held by some people that it would be able to detect everything that the chemical analysis failed to give. Patently, such claims have never been realized. Most of the metals and many of their alloys have been studied by means of the microscope, but a more complete knowledge is still desired. I do not think that anyone questions the value of the chemical laboratory as a method of control in metallurgical operations; still, the metallographic laboratory can render greater service when the results of its procedure are properly interpreted. Microscopic examinations when conducted by experts can more speedily explain the properties of both metals and alloys than can chemical analyses. The two, however, should be regarded as supplemental.

After reviewing everything, both for and against, the writer strongly affirms his belief in metallography as indispensable in metal manufacturing and fabricating processes, and that the foundry interests may profitably install apparatus to that end. Instances may be cited almost without end to justify the claim that appropriately guided scientific investigation pays—that it is a business asset. The time has arrived when all prejudices should be cast away, and when this method is appreciated more widely it will be recognized more widely as one of the most important advances in modern metallurgy.

Foundry Industry Leaps Forward

The past year is the first since 1910 which showed an increase in the net number of foundries in the United States and Canada. During each year between 1910 and 1916 the industry suffered a loss in the number of shops. This loss, which totaled 304 plants from April 1, 1910, to Aug. 1, 1916, was caused by the business depression which prevailed during part of this period and the tendency to concentrate manufacture by extending large plants and discontinuing the smaller shops. This latter procedure was the result undoubtedly of labor difficulties and inability to secure prompt shipments of equipment and supplies, conditions which have prevailed since the beginning of the war.

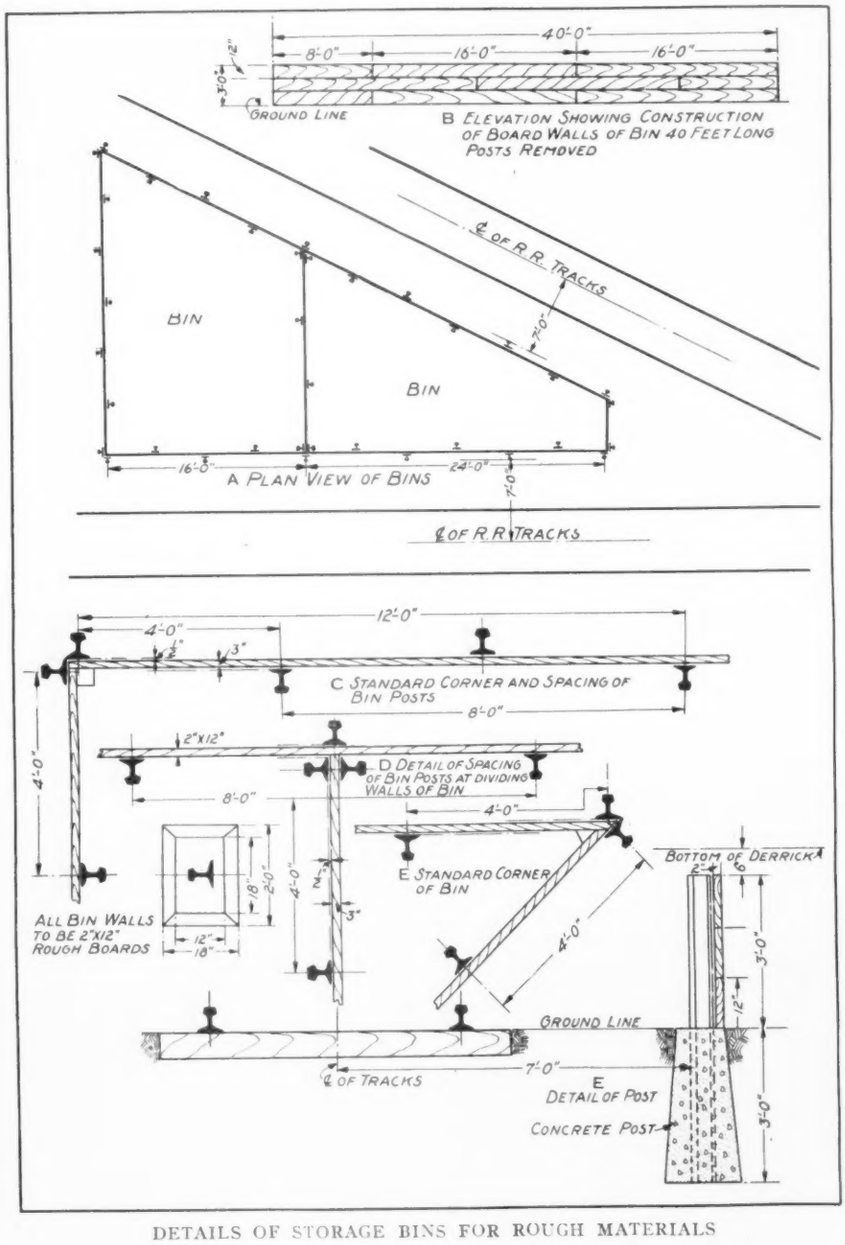
The net gain in casting plants in the last 15 months was 313, which, it will be noted, offsets the loss of the previous six years. According to figures compiled by THE FOUNDRY, 360 new plants have been added to the industry in the period under review, and during the same time, 47 shops have gone out of business entirely. A large number of concerns have been succeeded by new companies, have reincorporated or changed their names, but these are not included in the foregoing figures.

Pennsylvania leads the states in the number of new foundries with a total of 47. Ohio is a close second with 46. Illinois has gained 38 new foundries, 25 of which are located in Chicago. Michigan is next in line with 29 foundries, followed by New York with 28 and New Jersey with 27.

Design For Durable Storage Bins

By George W. Childs

In view of the present uncertain deliveries of raw materials, many manufacturers are finding it necessary to store large supplies to insure adequate stocks for emergencies. A group of storage bins, designed for coal, sand, ore, castings, scrap, etc., recently were constructed at the plant of the American Steel Foundries, Chester, Pa.



DETAILS OF STORAGE BINS FOR ROUGH MATERIALS

The bins are constructed of rough, yellow pine boards, 2 x 12 inches and 8 and 16 feet in length and scrap rails weighing 70 pounds and more per yard. The rails are 6 feet long and are set 3 feet deep in concrete piers. The bins vary in size and are located throughout the yard to suit plant conditions. They are numbered, and drawings are provided showing the locations of the various bins in the yard. A copy of the drawing, containing a numbered list and contents of each bin is conveniently displayed in the yard office.

In the accompanying illustrations, *A* shows a plan view of two bins, 12 feet and 24 feet in length, respectively, and the standard distance from the center line of the railroad tracks to the nearest side of the rail posts; *B* shows the construction of the board walls of bins 40 feet long. All board joints are staggered; *C* shows a standard corner and spacing of bin posts. The posts are spaced 4 feet apart and the clearance between the rails and the walls is ½ inch to allow the easy removal of the boards when required; *D* is the detail of the spacing of the bin posts at the dividing walls of the bin. *E* presents another form of the standard corner of bins. The drawing at *F* shows how the post should be set in the concrete pier. The rail extends 3 feet into the pier, and projects 3 feet above the ground line; *G* shows the standard location of the post relative to the centerline of the track.

The concrete piers are made of a mixture consisting of one part cement, two parts sand and four parts broken stone. The form of pier shown would required a wooden form, but it is said that this form need not be adhered to. As a substitute, the holes can be dug about 2 feet square and when the rail posts are placed in position the space can be filled with concrete. The rail posts are held in position in the holes, before the concrete is poured, by wooden strips extending from the sides of the posts to the sides of the holes.

It will be noted that the rail posts are staggered, every odd rail, as first, third, fifth, etc., is outside and every even rail as second, fourth, sixth, etc., is inside the board walls. This arrangement makes it possible to remove the boards one at a time, if desired, to allow wheelbarrows to be used in the bins.

It has been demonstrated at the plant of the American Steel Foundries that by placing the posts staggered as shown, the bins are amply strong for the pressure of the heaviest material coming against the walls.

For conveniently locating the inner and outer rail posts of the bins from the edges of the railroad tracks, wooden gages of the required dimensions should be provided.

Hard White Iron For Pipes

By W. J. Keep

Question:—We would like to have a cheap mixture suitable for making hard white iron for pipes, 8 feet long and 9 inches in diameter. The metal in these pipes is 1 inch thick.

Answer:—A cheap cupola mixture consists of white iron scrap, such as burned grate bars, with a slight addition of car wheels. Additions of wrought scrap to reduce the silicon low enough to make the castings white, also is advisable. The addition of a small amount of pure aluminum in the ladle will remove the gas and will make the iron fluid enough to produce sound castings. If you will visit a foundry where white iron sash weights are made, you will obtain considerable information regarding the practice which is similar to that you should pursue.

You might try a permanent cast iron mold for the outside of the pipe, which will give you the desired chill, together with a collapsible core. I also suggest that you melt the scrap in an air furnace.

How An Oil-Fired Malleable Furnace Operates

The Great Advantage of the Oil Furnace Lies in Its Uniformity of Operation—Labor Saving Also a Factor

AT THE session on malleable foundry practice at the annual meeting of the American Foundrymen's association held in Boston in September, J. P. Pero, superintendent, Missouri Malleable Iron Co., East St. Louis, Ill., chairman in charge of the meeting, described briefly the results of some interesting experiments on the use of fuel oil in place of coal for firing malleable melting furnaces. Mr. Pero said the oil fuel had proved entirely satisfactory in almost every way. Through the courtesy of the Missouri Malleable Iron Co. further particulars of this interesting innovation are now available.

The oil-burning furnace at the plant of the Missouri Malleable Iron Co. was specially designed for the purpose. It has now been in service about six months and the experimental period in its operation has been passed.

The furnace has a maximum capacity of 20 tons, but during most of the time in which it has been in operation 12-ton heats have been melted. It has not been practicable to melt larger quantities owing to the proximity of other furnaces which it has been necessary to keep in operation to supply the total amount of iron required for each day's work.

The general arrangement of the oil-burning furnace is shown in Fig. 1. The oil burner takes the place of the coal grate at the end. The customary top blast is provided and four 2½-inch top tuyeres have been installed. It will be noted the furnace is drawn down at the throat and that the roof slants straight from the bridgewall to the stack. The melting hearth, bungs, rabbling doors, etc., are arranged in the usual manner. The furnace has steel plate sides reinforced with I-beam buck stays. A monorail trolley is provided for handling the bungs.

Details of Oil Burner

The details of the oil burner are shown clearly in Fig. 2. A burner of standard design built by W. N. Best, New York, is provided. The oil passes through a meter and enters the burner under a pressure of approximately 10 pounds per square inch. It is important that this pressure be maintained at the correct value. The necessary pressure is provided by a small centrifugal pump. The oil also is preheated to a temperature of from 135 to 150 degrees Fahr. The temperature of the oil also has an important bearing on its proper atomization and combustion. The oil is atomized by steam at a pressure of approximately 60 pounds per square inch. The steam is superheated before arriving at the burner by passing through a coil in the combustion chamber. The oil and steam are intimately mixed at the burner, from which the finely divided particles are discharged at high speed resulting in combustion at maximum temperature.

The large volume of low pressure air necessary for the correct burning of the oil in the combustion chamber is supplied by an end-blast shown clearly in Fig. 2. A 12-inch blast pipe is provided and the air enters the combustion chamber directly under the burner.

The combustion chamber is an important part of the furnace and its proportions were very carefully worked out by experiment. It is approximately 7 feet in length and extends the full width of the furnace. When operating conditions are correct, the flame extends but a very little way over the bridgewall. The air for the end and top blasts is provided by a 30-inch blower of standard type manufactured by the Buffalo Forge Co., Buffalo. The blower is direct-connected to a 10-horsepower, 220-volt direct-current motor furnished by the Wagner Electric Mfg. Co., St. Louis. The necessary oil pressure is created by a small motor-driven centrifugal oil pump. The oil is stored in a tank conveniently

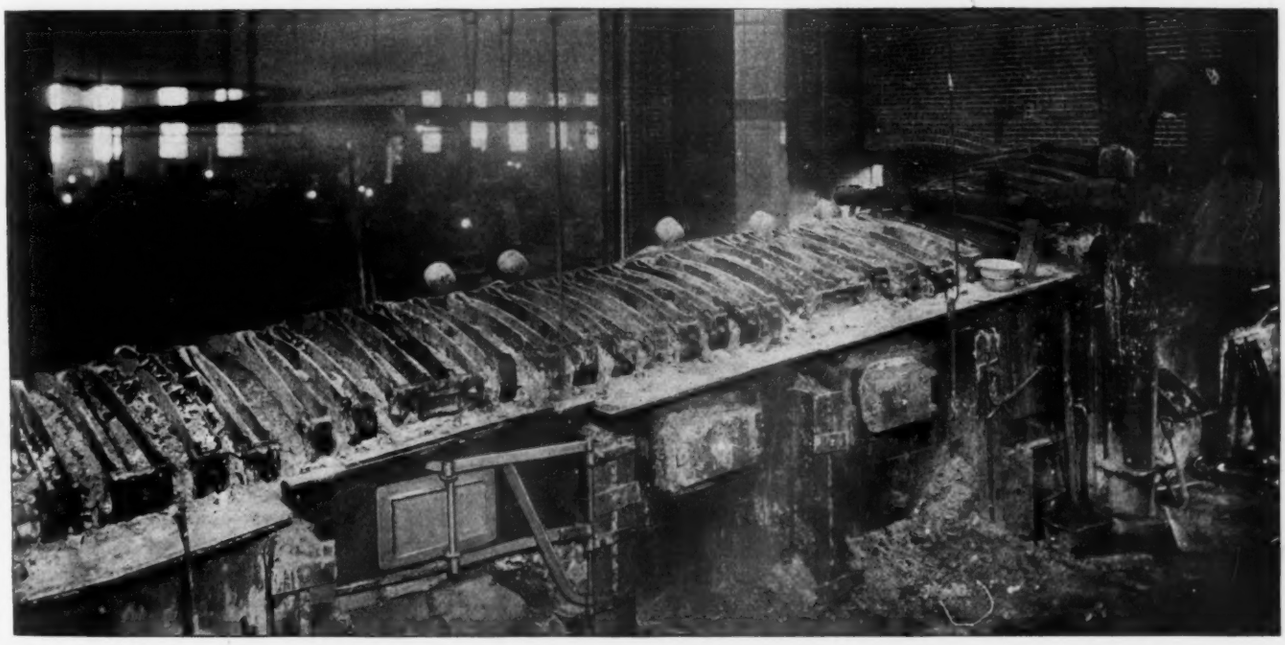


FIG. 1—GENERAL ARRANGEMENT OF OIL-FIRED AIR FURNACE SHOWING ROOF DESIGN AND IMPROVED DOOR

located near the receiving tracks. Another storage tank of 135,000 tons capacity is now under construction. Ordinary Oklahoma fuel oil of standard gravity is employed. At the present market it costs a little over 5 cents per gallon.

The arrangement of the oil piping leading to the burning, together with the location of the meter, pressure gage and oil-temperature thermometer are clearly shown in Fig. 2. The combustion of the oil and therefore the amount of heat generated in the furnace is controlled entirely by

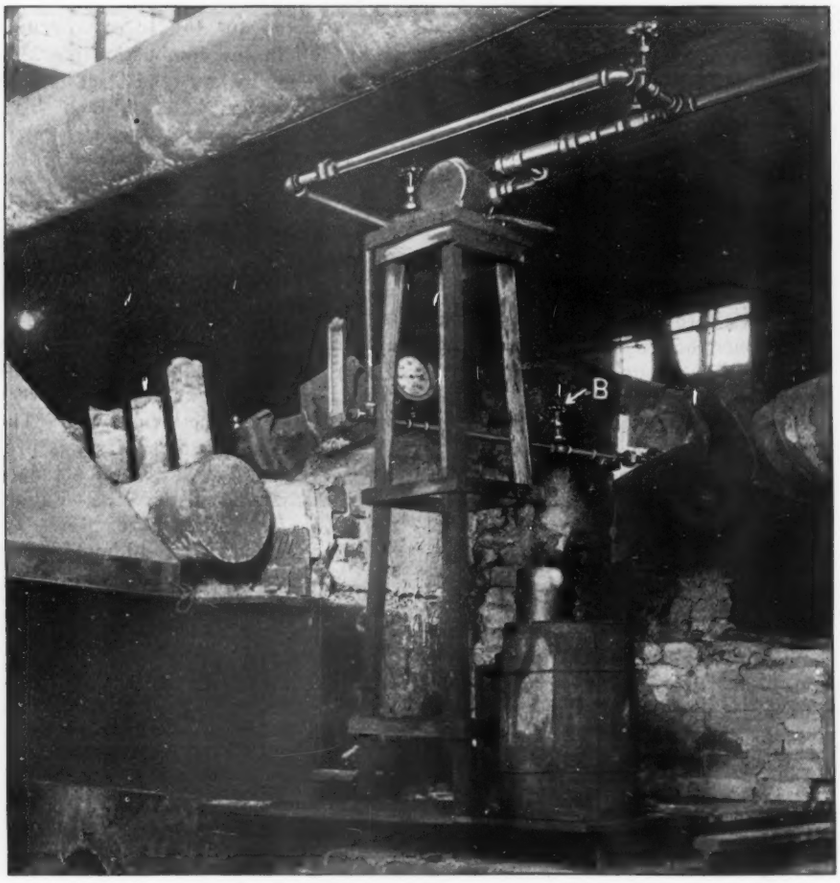


FIG. 2—ARRANGEMENT OF BURNER IN OIL-FIRED FURNACE

manipulating the small globe valve, *B*, Fig. 2, located in the oil-pipe line near the furnace.

One man can readily control the operation of the furnace. In the case of coal-fired furnaces from two to four men are required depending on the weather. Firing air furnaces with coal in hot weather is unusually arduous and it is during the summer months that the oil-fired furnace exhibits its greatest economy.

Oil Consumption Moderate

Records kept by the Missouri Malleable Iron Co. show that the oil consumption varies from 68 to 72 gallons per ton when melting 12-ton heats. If heavier heats were melted somewhat lower consumption could be obtained. The fuel cost when burning oil, therefore, is $3.40 to $3.60 per ton of iron melted. Coal-fired furnaces require about 750 pounds of good West Virginia gas coal per ton of iron melted.

When melting 12-ton charges the morning heat can be put through the furnace in from 4¼ to 4½ hours. No difficulty is experienced in melting the afternoon heat in 3½ hours. The furnace is equipped with doors of a new type one of which is shown at the left in Fig. 1. By means of the double hinge arrangement, which is clearly illustrated, the door always closes tightly on its seat thus reducing heat losses and preventing the escape of gas and flames. The door is carried by a steel frame which is hinged on one of the I-beam stays.

In commenting on the advantages of the oil-fired furnace at the meeting of the American Foundrymen's association, Mr. Pero made the following remarks: "I believe that it won't be long before we shall all get away from hand firing. One of the primary aims of the operator of an air furnace is to obtain uniformity of product. I know I am getting better control of the chemical content of the iron in the oil furnace than in any of my hand-fired coal furnaces. I believe also that the wear and tear on the oil-fired furnace is very much less than on the hand-fired furnaces. In addition, the heats are turned out more quickly and more uniformly, in fact, you can almost set your watch by the heats. We are so well pleased with our oil furnace on which we have been experimenting since last April that we have decided to equip three more furnaces with oil burners.

"Now our daily reports do not show any economy of oil over coal. There is a material decrease in labor cost and there is also less maintenance cost, but the great advantage of the oil furnace lies in its uniformity of operation. This results from the fact that the heats can be accurately controlled. You can oxidize if you want to and you do not have to oxidize much if you don't want to. All the control is centered in a little valve. The heat units are used to best advantage in the oil-fired furnace. I have been surprised to find that I can operate with the flame extending just a little way over the bridgewall and still obtain sufficient heat. The stack is not being burned out and there is not much unconsumed gas sent up the stack."

Little Journeys of the Flint Shot Man

An exceedingly interesting 45-page booklet, entitled "Little Journeys of the Flint Shot Man", has been published by the United States Silica Co., Chicago, which describes the use of flint shot for sandblasting castings in more than 60 plants throughout the United States. This booklet was compiled by R. R. Shuman of the Shuman Advertising Co., 110 South Dearborn street, Chicago, who personally visited all of these plants and first-hand information regarding their sandblasting operations are given. The first chapter points out the advantages of sandblasting over other methods of cleaning castings and this is followed by a chapter entitled "The preparation of Metal Surfaces", which should prove of interest to all foundrymen. The various types of sandblasting apparatus also are reviewed and suggestions are included for making use of the waste dust and also for disposing of the waste. This is followed by a study of sandblasting methods with flint shot in such plants as the Allis-Chalmers Mfg. and the Falk Co., Milwaukee; Chicago Hardware Foundry Co., North Chicago; National Malleable Castings Co.; and others, equally well known. The use of the sandblast in the automobile industry also is

reviewed at length and suggestions also are made for using flint shot for sandblasting purposes for preparing metal surfaces for enameling, rust-proofing, cleaning nonferrous metal castings, etc.

Titanium and Aluminum Bronze

A well-arranged and well-illustrated 16-page booklet devoted to titanium bronze, has been issued by the Titanium Bronze Co., Niagara Falls, New York. A few of the many purposes to which titanium aluminum bronze may be applied are outlined and illustrations are included of some of the many castings made therefrom. It is used to advantage for parts requiring great resistance to vibration and abrasion, strength and wearing qualities, as well as having acid-resisting properties, making it particularly adaptable for gears, feed valves, pump valves, plunger rings, pump rods, acid fittings and structural pieces. Comparative photographs of the wear of a phosphor bronze pinion gear and one made from titanium aluminum bronze, are included. These show only comparatively slight wear on the titanium aluminum bronze pinion gear as compared to that of the gear made from phosphor bronze.

A 12-page booklet issued by this company, devoted to die-cast titanium aluminum bronze, shows many intricate parts successfully made from this metal. A special foundry has been equipped for this work and die-cast parts are being introduced as economical substitutes for sand castings, drop forgings, etc.

Malleable Iron and Its Uses

By Henry F Pope

IRON, as it is run from the furnace and poured into the molds in the process of making malleable iron castings, is not malleable at all but is extremely hard and brittle. When broken, it shows a white fracture. But this brittle iron is of such composition that when subjected to the proper annealing heat for the requisite length of time, it is transformed into an iron with entirely different physical qualities. After annealing, instead of showing a white fracture it shows a black one, giving it the name of "black heart". This distinguishes the malleable iron made in this country from that made in Europe, which has a steely fracture, due to the fact that the carbon is almost entirely removed by oxidation in the annealing process. The black fracture of American iron is due to the fact that in the annealing process the carbon, which in the original casting was all combined, has been separated out by decarbonization and is now found as free carbon or graphite of non-crystalline form deposited between the molecules of the iron. This form of carbon is called by Ledebur "temper carbon", to distinguish it from its other forms. The presence of a large amount of temper carbon gives the material its black appearance.

A Few Physical Properties

The iron itself, therefore, is left almost entirely free from any combination with carbon and possesses the malleable quality of wrought iron. It can be bent without fracture and withstands great shock and stress without breaking. It has the superiority of wrought iron in the respect of malleability without the sometimes objectionable fibrous structure of that material.

Some one will say: "Why use malleable iron any more when steel castings may be had?" That is a plausible question, for great strides have been made in steel casting production and certain castings have been changed from malleable iron to steel with improved results; but there are several reasons why steel will never displace malleable iron for a multitude of articles. In the first place, in most cases if the steel could be produced in the form and section of the malleable casting, it would be more expensive and no better; for it must be remembered that while the tensile strength of malleable iron is somewhat below that of soft steel, its elastic limit is just as high, which means that it will stand just as much punishment as the steel. Furthermore, it is easier and cheaper to produce many articles in malleable iron.

Poor Standards Reflected by Some Makers

Malleable iron has, unfortunately, not been produced in conformity with the best standards by all of its makers, and the poor iron made by some has brought much discredit upon the industry as a whole. There is no justification for this, because the inferior metal can be so easily distinguished from the good by the examination of the fractures of removed test lugs. All important castings should have test lugs cast on them for this purpose. Many manufacturers have, however, for several years given serious scientific study to their product with wonderfully good results, so that from many of them malleable iron can now be obtained of uniform quality and of greatly increased tensile strength without any sacrifice of ductility; for one peculiar feature of malleable iron is that while the tensile strength increases, the elongation also increases. This is not true of any other commercial metal.

There are two essentials necessary in the production of malleable iron. One is the proper composition of the hard iron and the other the proper heat treatment in the annealing process. With increased knowledge and with better practice, the former has been greatly improved and the latter is secured by a proper observation of the temperatures. The quality of malleable iron will doubtless be improved by the use of the electric furnace, which practically insures a proper mixture before the iron is poured, besides eliminating objectionable oxides.

Wide Range of Uses

Thus it can be seen that malleable iron has a usefulness which is entirely its own and which cannot be taken away. Years ago it began to be used advantageously for agricultural implements, all sorts of farm tools, wagons and carriages, harnesses, stoves, pipe fittings, and for many other purposes. Later, the railroads began to use it, for many parts of cars could be made lighter and less subject to fracture by the substitution of malleable for gray iron. The railroads also used it in places where the iron is exposed to the corrosive action of the weather, for malleable iron is as noncorrosive as any of the iron products and much more so than steel. More recently malleable iron has become popular in automobile construction. Other good qualities are its high permeability and its low magnetic hysteresis, qualities which render it desirable for certain electrical machinery.

Pure nickel has a lower resistivity than iron. At temperatures of 800 to 1000 degrees Cent. iron has a durability of 9 minutes, as against 32 hours for nickel.

Presented at the Cincinnati meeting of the American Iron and Steel institute, Oct. 26 and 27, 1917. The author is president, National Malleable Castings Co., Cleveland.

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Co-operation Thrives Under Stress

ONE of the subjects frequently discussed by manufacturers is that of co-operation between various departments. During the past decade no technical program has been considered complete unless it contained a paper on some phase of co-operation. Engineers have been urged to work in harmony with the operating heads, and employer and employe have been requested on each occasion to get together on a common basis.

It must be gratifying to the men who have persistently advocated co-operation to find that the war is effectively accomplishing what they have failed to do without its aid. No greater example of harmony between the component parts of a great industrial machine is afforded than the development of the standardized motors for the aeroplanes and motor trucks to be used by the government in France. In each case eminent engineers gladly contributed their genius to the perfection of an engine designed to simplify the work of manufacturers. Now that the designs have been completed the task has been shifted from the shoulders of the designing engineer to those of the production engineer and the operating officials. That these men have fully sensed their responsibility is indicated by the press reports announcing the early completion of motors constructed from the drawings sent out by government engineers. All that remains to make the triumph of industrial co-operation complete is for the manufacturers to turn out the standardized motors in such quantities that the American forces in Europe will never want for trucks or planes.

Trade Outlook

AFTER more than a month of groping about in the dark, manufacturers are beginning to grasp the significance of government price fixing. The foundry industry, like all other branches, was forced to tread water for a few weeks pending the determination of differentials and other details necessary to make the schedule operative. At the present time the prices of foundry iron and coke have been well established and sales of these materials are being made at the government quotations. Hundreds of thousands of tons of foundry and malleable iron have been sold at the fixed prices of $33 and $33.50 during the past few weeks. These sales call for delivery during the first half of 1918. Although the placing of freight cars for coke shipment has received the attention of the priority board, the car supply has not yet reached the promised 100 per cent basis. During the third week in October the average supply was 75 per cent, a ratio not calculated to aid the coke-oven operator in maintaining a reliable force of labor. Coke is held at $6, Connellsville. Other prices established by the government are as follows: Basic iron, $33, valley; gray forge, $32, valley; and malleable iron, $33.50, valley. Bessemer iron has been set at $36.30, valley, subject to revision.

New Equipment for the Foundry and Pattern Shop

Fool-Proof Electric Switch—New Type of Roll-Over Machine—Gravity Conveyor—Sand Tempering Machine—Arch for Annealing Ovens

THE H. W. Cooper Saddlery Hardware Mfg. Co., Moline, Ill., now makes a complete line of hand squeezers, having added two types of portable machines. Heretofore this company built only machines of the stationary type, but to complete the line and to meet the needs of the foundry trade it was decided to add the two portable machines. One of these portable machines straddles the sand pile and the other follows the sand pile as it is depleted in the making of molds.

PORTABLE SQUEEZER MOLDING MACHINE

All the operating parts of these machines are above the table and the number of these parts has been reduced to a minimum. The swinging head is balanced on hardened steel centers and as it can be readily swung by the molder it is convenient both for bench molding and squeezer work. All parts are made of steel, malleable iron and semisteel castings. Flasks up to 12 x 24 inches can be handled and the machines are especially adapted for work in gray or malleable iron and brass or aluminum foundries. One of the machines is shown in the accompanying illustration, which indicates how the body of the machine clears the sand heaps.

"Turning Waste Into Profit" is the title of a 28-page pamphlet issued by the Prest-O-Lite Co., Indianapolis, which is devoted exclusively to the possibilities of reclaiming broken and worn machinery and metal parts for service by the oxy-acetylene process. Containing 82 illustrations it pictures and describes representative reclamation welding work in practically every branch of industry. This booklet points the way for the economical and rapid recovery of many parts that otherwise might be scrapped.

New Type of Roll-Over Molding Machine

A unique roll-over molding machine has been developed by the American Molding Machine Co., Terre Haute, Ind., from designs made by W. C. Norcross, president and general manager. It is of the combined roll-over jolt type and is operated with compressed air. A single air cylinder controls both the roll-over and the ramming functions instead of separate units, usually employed. The three accompanying illustrations show the machine in different operating positions. Fig. 1 is a view of the mold before it is completely rolled over and dropped upon the jolting table. In Fig. 2, the mold is shown upon the jolting table and

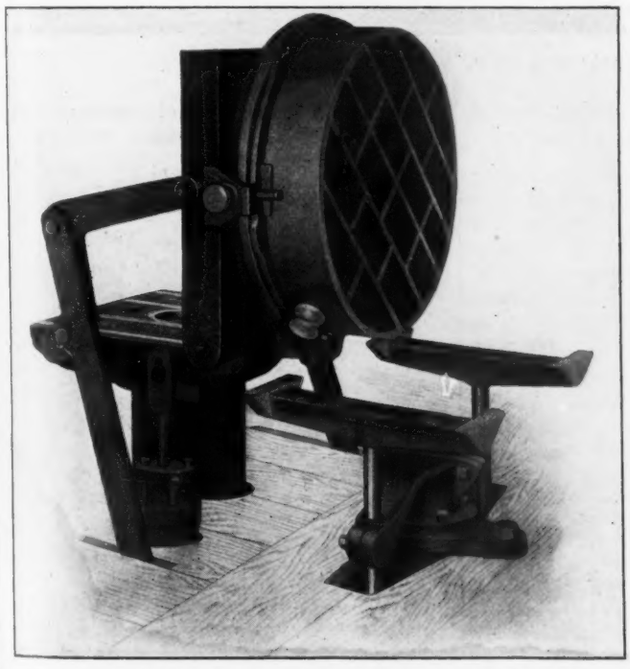


FIG. 1—MOLD BALANCED IN CENTER OF ROLL-OVER OPERATION

FIG. 2—MOLD ROLLED OVER IN PLACE ON JOLT TABLE

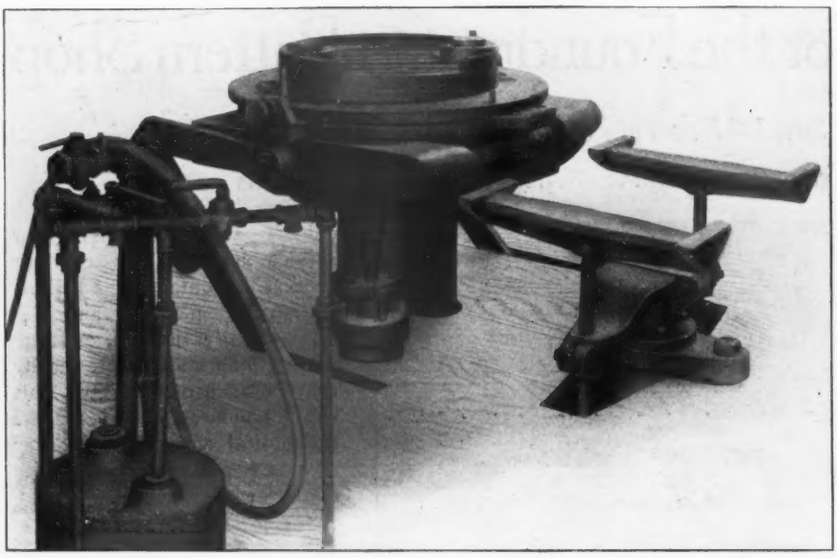


FIG. 3—RAMMING IS QUICKLY ACCOMPLISHED BY A 10-INCH AIR CYLINDER

Fig. 3 is a view of the machine showing the ramming operation. When jolting the mold, the cylinder operates in the usual manner; however, for the roll-over operation, a unique link motion and an automatic latch are brought into play. The mold is balanced at the center and little effort is required to roll it over. An oil-filled balancing cylinder, placed beneath the table, is provided to steady the roll-over operation. The flask is turned onto an automatic ball-and-socket leveling device that is self-compensating for any irregularities in the flask or the mold. When these supports take their bearing, the weight of the mold causes the hinged socket to grip the ball positively.

Gravity Conveyors for Foundry Materials

Gravity conveyors, through their several advantageous characteristics, have created a distinct field of application where it is desired to move materials economically and rapidly. The introduction of this labor and time saving means of handling materials has eliminated much lost motion and has served to effect considerable savings. In foundries, pig iron may be moved with a minimum of effort from railroad cars to the storage pile, from the storage pile to the cupola; molds may be carried to the cupola spout, and the finished castings conveyed from place to place by portable sections of gravity conveyors. The accompanying illustration shows a conveyor made by the Minnesota Manufacturers' association, North St. Paul, Minn. The steel rollers are provided with ball bearings which operate in hardened steel races. A special lock nut and washer holds the ball bearing stud securely in the angle iron side frame, and permits of easy removal of single rollers.

UNLOADING PIG IRON WITH GRAVITY CONVEYOR

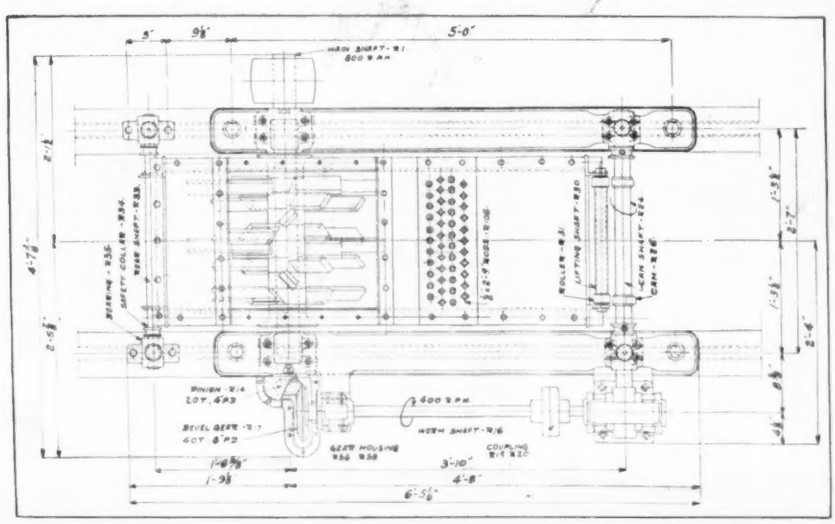


DIAGRAM SHOWING CONSTRUCTION OF SAND REVIVIFYING MACHINE

Molding Sand Revivifier

In the operation of a continuous foundry, it is necessary to give the problem of keeping the sand in proper conditions careful attention. In some cases it has been found the sand has a tendency to form small hard balls which impart rough surfaces to the castings. In other foundries it has been found that the sand gets so hot that the molds dry out before they are poured. In an effort to overcome these difficulties, the Link-Belt Co., Chicago, has designed a new machine which is known as a molding sand revivifier. The principal element of the machine is a horizontal shaft on which beater arms, made of flat bars, are mounted. These arms are set at opposing angles so that the sand delivered to one side of the machine is thrown diagonally across to the other side, thus receiving a thorough mixing and aerating. The main shaft runs at 800 revolutions per minute and it is claimed that sand balls and hard lumps are promptly broken up by the beater arms.

The beater throws the sand against

a curtain of hinged rods which prevents the air from swirling around inside the shell of the machine and carrying the sand with it. The whole shell is pivoted at the rear and is so suspended that it is lifted a distance of 1½ inches about 30 times a minute by a cam. The cam drops the shell on a block of wood and the shock causes the shell and rods to vibrate, with the result that particles of sand that ordinarily would adhere to the mechanism are shaken off. It is claimed, therefore, that the machine is always clean and in conditions to do effective work. Also it is stated the usual increase in the temperature of the sand incident to pouring is reduced at least 50 per cent by passing the material through this machine.

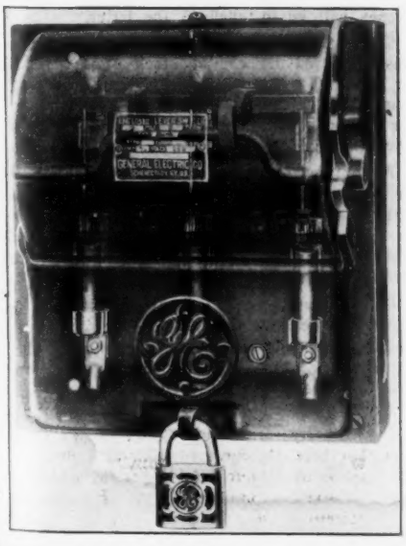
Roof Arch for Annealing Ovens

A flat, suspended-type roof arch for annealing ovens in malleable foundries has been developed by the M. H. Detrick Co., Chicago. This arch, which is the result of considerable experimental work, is said to have indicated through trial installations that a uniform distribution of heat may be maintained which eliminates the possibility of hard malleables due to unequal annealing in various parts of the oven.

The accompanying illustration shows a flat, suspended arch in use at the plant of the Rockford Malleable Co., Rockford, Ill. In this type of roof arch, the fire bricks are suspended like pendulums from I-beams which rest upon the side walls. This construction eliminates the side thrust inherent to sprung arches and does away with buck-stays.

The fire bricks used in the arch of the Rockford furnace are 6 x 10½ x 10½ inches and are grooved on the top surface to receive the flange of a casting having an I-beam cross-section. Each casting supports 10 bricks, making each roof section 6 inches wide and 5 feet long. Successive rows suspended from I-beams resting on the side walls and spaced at 5-foot intervals comprise the roof of the oven. Eyelets in the castings permit the lifting of any row from the roof as desired. The opening in the roof thus made provides space to remove any brick in the row that may require replacing. Expansion and contraction are matters of automatic adjustment as each brick or tile is supported individually and no strains or stress are set up in the arch as a whole.

FLAT SUSPENDED TYPE ROOF ARCH DESIGNED FOR ANNEALING OVENS



ENCLOSED LEVER SWITCH

A Fool-Proof Electric Switch

A new type of lever switch enclosed in an iron casing, recently has been developed by the General Electric Co., Schenectady, N. Y. The accompanying illustration not only shows the exterior protective casing, which is of sheet metal, but also reproduces in phantom the working parts and the slate base. The padlock prevents "outsiders" from tampering with the fuses in the lower part of the switchbox. Moreover, the switching lever at the upper right-hand side cannot be closed while the covering over the fuses is open, and vice versa.

When two or three operators are involved it has been observed that although one of them may throw on the switch with perfect safety, he may endanger another operator working on a machine whose motor gets its current through the switch. To meet this conditions three locks, each controlled by a different individual, may be used, thus enabling all operators to keep in touch with what is going on. The switches can also be provided with spring catches which must be pressed down while the switching lever is moved. Both hands are thus required to switch the electricity on or off and further safety is achieved.

Plan Program for 1917-1918

The Birmingham branch of the British Foundrymen's association has outlined an exceedingly comprehensive program for the coming season. The papers to be presented at the various meetings follow:

Oct. 27.—Presidential address by J. Shaw, of Dudley, on "The Relationship between the Drawing Office Pattern and Molding Shops."

Nov. 24.—Lecture by Prof. T. Turner, the University, Birmingham, on "The Use and Construction of Graphic Diagrams."

Dec. 8.—Joint meeting with the Staffordshire Iron and Steel Institute. J. E. Hurst, of Manchester, will present a paper on "The Re-heating of Gray Cast Iron with Special Reference to Combustion Engines."

Jan. 26.—M. Riddell, of Glasgow, president of the Scottish branch of the British Foundrymen's association, will present a paper on "Permanent Molds."

Feb. 23.—Second joint meeting with the Staffordshire Iron and Steel Institute. J. E. Fletcher, of Dudley, president of the Institute, will lecture on "The Production of Steel Castings."

March 9.—"Jolt Ramming Molding Machines" will be discussed, the subject to be introduced by H. Pemberton, of Derby.

March 23.—Annual meeting and election of officers. Three papers also will be discussed as follows: "Coke-fired Furnaces," by H. L. Reason, Birmingham; "Gas-fired Furnaces," by F. H. Hurren, Coventry and "Oil-fired Furnaces," by Andrew Harley, Coventry.

In making blacking for molds and cores, one-half pint of molasses to a common-size pail filled with blacking is all that should be used.

WHAT THE FOUNDRIES ARE DOING

Activities of the Iron, Steel and Brass Shops

The Magnus Co., 22 Brush street, Detroit, brass founder, is building a $35,000 plant.

The Wizard Foundry Co., North Attleboro, Mass., will erect an addition to its foundry, one story, 30 x 100 feet.

The American Car & Foundry Co., Huntington, W. Va., will erect machine and blacksmith shop at a cost of $30,000.

The Gray Foundry, Inc., Poultney, Vt., is building an addition, 28 x 70 feet. A heating plant, 20 x 25 feet, also will be built.

Leitelt Bros., 7731 South Chicago avenue, Chicago, are building a brass foundry, 46 x 77 feet, at a cost of $8000.

A permit has been granted the Arth Brass & Aluminum Castings Co., Cleveland, to build a foundry addition, 18 x 20 feet.

The Golden Gate Brass Mfg. Co., San Francisco, will build a $12,000 foundry on Second street.

A contract has been awarded for the erection of a $35,000 foundry for the Jacob Wilson estate; J. W. Harrison is manager.

The Williams Mill Mfg. Co., Texarkana, Ark., recently incorporated with $100,000 capital, will erect a foundry and machine shop.

The Standard Brass Castings Co., Oakland, Cal., contemplates the erection of a $30,000 plant addition on a site recently purchased.

A contract has been awarded by the Pequonnock Foundry, Inc., Bridgeport, Conn., for an addition to its foundry.

The Buffalo Foundry & Machine Co., Buffalo, has increased its capital stock from $500,000 to $1,500,000.

The Regent Brass Foundry Co., Marysville, O., will increase the number of furnaces in its foundry from five to 16.

The capital stock of the Coeur d'Alene Hardware & Foundry Co., Wallace, Idaho, has been increased from $500,000 to $1,000,000.

The Richards Mfg. Co., Bloomsburg, Pa., is now operating its foundry which has been idle for a long period.

The Canada Iron Foundries, St. Thomas, Ont., has purchased a plant and will equip it for the manufacture of special castings.

The Woodward Machine Co., Wooster, O., is building a plant, 80 x 110 feet. The company's foundry at Orville, O., will be removed to Wooster.

The Gilliam Mfg. Co., Canton, O., has increased its capital stock from $800,000 to $1,500,000 to provide funds for erecting further additions to its foundry.

The Buffalo Foundry & Machine Co., Fillmore avenue and East Ferry street, Buffalo, will erect a 1-story, 28 x 174-foot pattern shop at a cost of $20,000.

The Bassick Co., Universal Caster & Foundry Co. division, 574 Ferry street, Newark, N. J., will erect a 1-story, 75 x 100-foot addition to its foundry.

A permit has been obtained by the Acorn Refining Co., 8205 Franklin avenue, Cleveland, to erect a gray iron foundry, 60 x 116 feet.

A foundry is being erected by the Standard Plating Co., Anderson, Ind. G. A. Robinson is manager of the company.

The Federal Steel & Mfg. Co., Minneapolis, will build a plant, including a foundry, 100 x 125 feet, and three machine shops, each 110 x 400 feet. The estimated cost is $500,000.

The Standard Crucible Steel Castings Co., 719 Thirty-first street, Milwaukee, will build a brick and concrete addition, one story, 30 x 60 feet.

Plans have been prepared for an electric steel foundry, 80 x 140 feet, to be erected for the Edward Valve & Mfg. Co., East Chicago, Ind. The estimated cost is $15,000.

The West Michigan Steel Co., Muskegon, Mich., is building two additions to its foundry, 42 x 150 feet and 48 x 100 feet, at a cost of $21,000.

An addition will be erected by the Buhl Malleable Co., Adair and Wight streets, Detroit, on property recently purchased adjoining its present plant.

Plans have been prepared for a foundry and forge plant to be erected for the Southern Illinois Machine & Foundry Co., Murphysboro, Ill. The estimated cost is $35,000.

A $200,000 plant, 90 x 200 feet, will be erected at Christina and Exmouth streets, Sarnia, Ont., by the Romeo Foundry Co., Port Huron, Mich.

Edward C. Aylward, formerly associated with the Aylward Sons Co., Neenah, Wis., will establish a gray iron foundry in that city. A 60 x 90-foot plant will be erected.

A contract has been awarded for the erection of a 2-story, 26 x 40-foot addition to the plant of the Stillman White Foundry Co., Providence, R. I.

The Canadian Brass Co., St. Catharines, Ont., manufacturer of plumbers' supplies, brass fittings, etc., will build an addition to its plant to cost $15,000.

The Pacific Car & Foundry Co., Seattle, has been incorporated with $1,000,000 capital, by William Pigott, O. D. Colvin, John, James F. and Robert L. Twohy.

The James A. Brady Foundry Co., Thirty-fifth street and Ashland avenue, Chicago, has increased its capital stock from $25,000 to $300,000.

The Connecticut Brass Foundry Co., Waterbury, Conn., has been incorporated with a capital of $10,000 by Franklin W. Cohen, Samuel I. Liftig and Henry L. Silver.

Prack & Perrine, 803 Keystone Bank building, Pittsburgh, are preparing plans for a $50,000 foundry, 165 x 241 feet, to be erected for the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

The West Bend Aluminum Co., West Bend, Wis., will build two additions to its plant, 75 x 195 feet and 50 x 60 feet, respectively. Abount $75,000 will be expended on the buildings and equipment.

The Nelsen Mfg. Co., Chicago, contemplates the erection of a one-story plant at Southport and Diversey avenues, which will include a foundry, enameling and case-hardening departments and general offices.

A gray iron foundry has been established in Milwaukee by the recently organized Atlas Foundry Co. The new company has been capitalized with $10,000, by Orvel A. Meyer, formerly of La Salle, Ill., and George P. Gerlinger, vice president of the Gerlinger Steel Casting Co., West Allis.

The Mt. Vernon Foundry & Engineering Co., Mt. Vernon, O., has been incorporated with $100,000 capital by James J. Sexton, George L. Mooney, R. C. Evick, John W. Mullin and W. L. Robinson.

The Keystone Brass Co., New York, has been incorporated with $10,000 capital to engage in the foundry business. The incorporators are E. A. Alafberg, S. L. Cohen and G. C. Norton, 617 Fifth avenue.

Barker & Co., New York, have been incorporated to conduct a foundry and machine shop business with $500,000 capital stock. A. Skillman, E. E. Hurley and A. Foshay, 120 Broadway, are the incorporators.

The Suffolk Casting & Supply Co., Boston, has been organized with a capital stock of $25,000. The incorporators are J. Jefferson Richards, L. B. Ellis and Sylvester D. Devlin, Everett, Mass.

The South Jersey Foundry Co., Camden, N. J., has been chartered with $250,000 capital to engage in the manufacture of cast iron pipe. The incorporators are Herbert J. Koehler, K. L. Fraiser and J. F. Sutton.

The J. L. Simpson Co., Bellefontaine, O., has been incorporated with $25,000 capital to engage in the manufacture of castings. J. L. H. S., E. M. and E. J. Simpson and Harry H. Morrow are the incorporators.

The Chelsea Foundry Co., Chelsea, Mass., has incorporated with a capital stock of $35,000. Edward F. Maguire, Morris M. Broomfield and P. M. Broomfield are the incorporators.

The Davis Mfg. Co., Enid, Okla., will build a plant, including a machine shop and foundry, three stories, 50 x 110 feet, to cost $50,000. The company will manufacture rotary separators and threshers.

The Herreshoff Mfg. Co., Bristol, R. I., has awarded the contract for a 2-story, 30 x 36-foot addition to its foundry and a 3-story, 60 x 80-foot storage building. Electric traveling cranes will be installed in the latter.

The Lansdale Foundry Co., Lansdale, Pa., has increased its capital stock from $25,000 to $100,000. The capacity of the plant recently has been doubled to provide facilities for producing work for the United States government.

A contract for a 280 x 300-foot foundry to be erected at the United States arsenal, Watertown, Mass., has been awarded to the Stone & Webster Engineering Corp., Boston. The total expenditure for building and equipment will approximate $800,000.

R. W. Benbridge, H. C. Benbridge and B. H. Benbridge have incorporated the Benbridge Foundry, Inc., Terre Haute, Ind., with a capitalization of $25,000. The new company will take over the plant of the United States Scale & Foundry Co.

The Liberty Ordnance Corp., New York City, has been incorporated with $15,000 capital stock to conduct a foundry and machine shop. The incorporators are F. H. Brownell, T. Pomeroy and R. P. Branley, 2386 Grand avenue.